Safety Data Package

Flight and Ground Operations

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G-772

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LIST OF ACRONYMS AND DEFINITIONS

Al	Aluminum
COLLIDE	COLLisions Into Dust Experiment - the G-772 Payload
EEPROM	Electrically Eraseable Programmable Read Only Memory
EMP	Experiment Mounting Plate
GAS	Get-Away Special
GCD	GAS Control Decoder
GSFC	Goddard Space Flight Center
IBS	Impactor Box System
JSC	Johnson Space Center
JSC-1	Johnson Space Center Lunar Soil Simulant
JVC	Japan Victor Corporation
KSC	Kennedy Space Center
LED	Light Emitting Diode
MC	Microcontroller (Intel 80C51GB)
NASA	National Aeronautics and Space Administration
PPC	Payload Power Contactor
PRV	Pressure Relief Valve
regolith	loose, unconsolidated material on the surface of a natural object, such as a moon or asteroid
SAE	Society of Automotive Engineers
SCC	Stress Corrosion Cracking
STS	Space Transportation System
VDC	Voltage Direct Current
VTL	Verification Tracking Log

Applicable Documents

GAS Experimenter Handbook
GAS Safety Manual
GSFC 731-0005-83
JSC 20793 Manned Space Vehicle Battery Safety Handbook
JSC 26943 Guidelines for the Preparation of Payload Flight Safety Data Packages and Hazard Reports
JSC 09604
KHB 1700.7B Space Shuttle Payload Ground Safety Handbook
MSFC HDBK 527
MSFC-SPEC-522B
NSTS 1700.7B Safety Policy and Requirements for Payloads Using the Space Transportation System
NSTS 18798 Interpretations of NSTS Payload Safety Requirements

1.0 Introduction

The GAS canister will be sealed and evacuated prior to launch. The GAS canister pressure relief valve will be filtered. The GAS canister internal environment will remain inert throughout the Space Shuttle mission, since the total energy that G-772 possesses is insufficient to breach the sealed nature of the GAS canister under worst case conditions. In addition, the failed experiment structure will be fully contained under the worst possible STS load environments. All materials are non-hazardous and have been found to be compatible with each other as well as the GAS Carrier System and Space Shuttle environments. Therefore, G-772 has been classified as a 'Class B' (Benign) payload in accordance with JSC Letter TA-91-029.

1.1 Objective

Planetary ring systems are collisionally evolved structures. In the optically thick rings of Saturn and Uranus, a typical ring particle suffers collisions in time intervals of hours. These collisions take place at velocities determined by the dispersion velocity of ring particles as they orbit the planet on nearly identical Keplerian orbits. Collision velocities may be as low as 1mm/s in some ring regions and in excess of 1 m/s in others, depending on perturbations by massive bodies within the rings. Macroscopic ring particles (larger than about 1 cm in radius) may be coated with a layer of fine dust created by micrometeoroid bombardment of the particles. This layer of regolith is the source of dust that has been observed in all the planetary ring systems. Since dust particles have short dynamical and physical lifetimes in planetary ring environments (typically less than a century), the levels of dust in planetary rings are determined by a balance between the loss processes and collisional release of dust from the macroscopic ring particles. Some dust is released directly by micrometeroid impacts onto large ring particles, and some is released from the ring particle regoliths when two ring particles collide. The energies involved in these collisions is too low for the collisions to be studied experimentally in a one-Earth-gravity environment. This GAS payload (COLLIDE) will be the first experiment to study the effects of collisions into a regolith at velocities like those that occur in planetary ring collisions. This collisional regime is also applicable to the early stages of planetary accretion when a distribution of objects ranging in size from micron-sized dust up to centimeter-sized pebbles accreted to make planetesimals.

The physical quantities to be measured are (1) the amount of dust ejected from a regolith layer, (2) the speed of the ejecta, and (3) the angular distribution of the ejecta trajectories. These quantities may depend on the mass and velocity of the impactor, and on the amount of regolith available. These parameters will be varied in the experiment, and the resulting data can then be placed in the context of the large set of ground-based data on high energy collisions and impacts. The data will help constrain the unseen population of ring particles that supply the observed dust rings, and will provide a constraint on models of dust ring evolution.

1.2 Experiment Concept

Six independent collision experiments will be conducted with different impact parameters (impactor size, impactor velocity, depth of regolith layer). Each collision experiment will take place in a self-contained Impactor Box System (IBS). Each IBS consists of a tray for the target regolith material, a launcher, and a lighting system. Prior to the experiment, the target material is held in place by a door. Data will be taken by two video camcorders which will record the impacts on videotape as they take place. The impactors are launched by springs into simulated lunar regolith material. A mirror in each IBS provides a secondary view of the impact. Analysis of the videotapes will provide information on the angle and speed of the ejecta, and some information on the amount of ejecta and the time history of crater formation in the regolith layer. The ejected regolith will be separated from the rest of the regolith after impact by closing the door. This will allow a more accurate determination of the ejected mass when the experiment is returned following the flight.

1.3 Operational Scenario

The activity sequence for the experiment is shown in Table 1.3-1. The experiment power circuit will be closed when Relay A is latched HOT by the GAS canister barometric switch. For mission success camera temperatures will be monitored and the cameras will be turned on to maintain the cameras within operating range and out of the tape degradation temperature range (tapes degrade below 0 degrees centigrade). Relay B is latched HOT to trigger the microcontroller to begin the experiment. An internal timer will signal the microcontroller to begin the experiment if Relay B is not latched HOT within 24 hours of Relay A latching HOT. The microcontroller will initiate the experiment if it senses that the battery voltage has dropped to 11.0 Volts. G-772 requests that the experiment be initiated at the first opportunity during the first 24 hours of flight meeting the requested minimal accelerations for the 21 minute duration of the experiment. A microcontroller board controls execution of the experiment. Once Relay B is latched HOT, the microcontroller begins recording temperature, acceleration, and pressure data and begins a timing program which executes the main functions of the experiment.

First, videocamera 2 is turned on. The microcontroller board controls the operation of the cameras and commands videocamera 2 to begin recording. Next, the light emitting diodes in IBS 3 are turned on for illumination of the first impact experiment. The door of IBS 3 is opened by the door stepper motor in 10 seconds. A voltage of 6V is applied to a shape memory alloy circuit resulting in a current through each wire of 0.75 Amps causing the alloy to contract. This pulls a spring loaded pin which holds the launcher door in place. The launcher door spring pushes the door open and the projectile is launched by a pusher attached to a launcher spring which is epoxied to the rear of the launcher with 2216 structural epoxy. The projectile reaches the powder surface in 0.1 to 10 seconds, depending on the IBS. The ejecta launch velocities, crater formation, and launch angle are recorded by the camera. For mission success, the door is closed 30 to 180 seconds later, depending on the IBS. This isolates the remaining target powder in the target tray for measurement after the experiment is returned allowing the total amount of ejected material to be determined. The projectile will be contained in the IBS, either in the target tray compartment or the launcher compartment. The lights in the IBS are turned off. After a delay of several seconds, the entire process is repeated for the next IBS. After the third collision experiment, camera 2 is turned off and camera 1 begins recording. Then the next set of three collision experiments begins. The six IBS's are operated in sequence in the same manner.

After the sixth collision experiment has been completed and the lights in the sixth IBS have been turned off, the camera stops recording. For mission success, temperature sensors will trigger the camera power to be turned on if the temperature within the camera sealed containers drops below 5 degrees Celsius and will remain on until the temperature reaches 10 degrees Celsius. Heat is provided by the camera electronics. Relay A will be switched to LATENT before re-entry.

Table 1.3-1 Activity Sequence

EVENT	RELATIVE TIME (min:sec)	DURATION (seconds)	DELAY (seconds)	EFFECT
Relay B is latched HOT OR battery voltage drops to 11.0 Volts OR experiment timer reaches 24 hours.	0:00	0.00	5.00	Experiment begins.
MC turns on camera 2.	0:05	0.00	240.00	Camera 2 is on in record mode.
MC signals camera 2 to record.	4:05	1.00	5.00	Camera 2 begins recording on videotape.
MC turns on LEDs in IBS #3.	4:11	0.00	5.00	IBS #3 has internal illumination.
MC runs IBS #3 stepper motor.	4:16	10.00	1.00	Stepper motor opens target tray door of IBS #3 and stops.
MC applies current to IBS #3 muscle wire.	4:27	4.00	30.00	Muscle wire contracts, and projectile is released in IBS #3.
MC runs IBS #3 stepper motor.	5:01	20.00	5.00	Stepper motor closes target tray door in IBS #3 and stops.
MC turns off LEDs in IBS #3.	5:26	0.00	1.00	IBS #3 experiment complete.
MC signals camera 2 to stop recording.	5:27	1.00	5.00	Camera 2 stops recording.
MC turns off camera 2.	5:33	0.00	1.00	Camera 2 is off.
MC turns on camera 1.	5:34	0.00	240.00	Camera 1 is on in record mode.
MC signals camera 1 to record.	9:34	1.0	5.00	Camera 1 begins recording on videotape.
MC turns on LEDs in IBS #6.	9:40	0.00	5.00	IBS #6 has internal illumination.
MC runs IBS #6 stepper motor.	9:45	10.00	1.00	Stepper motor opens target tray door of IBS #6 and stops.
MC applies current to IBS #6 muscle wire.	9:56	4.00	30.00	Muscle wire contracts, and projectile is released in IBS #6.
MC runs IBS #6 stepper motor.	10:30	20.00	5.00	Stepper motor closes target tray door in IBS #6 and stops.
MC turns off LEDs in IBS #6.	10:55	0.00	1.00	IBS #6 experiment complete.
MC signals camera 1 to stop recording.	10:56	1.00	5.00	Camera 1 stops recording.
MC turns off camera 1.	11:02	0.00	1.00	Camera 1 is off.
MC turns on camera 2.	11:03	0.00	5.00	Camera 2 is on in record mode.
MC signals camera 2 to record.	11:08	1.00	5.00	Camera 1 begins recording on videotape.
MC turns on LEDs in IBS #1.	11:14	0.00	5.00	IBS #1 has internal illumination.
MC runs IBS #1 stepper motor.	11:19	10.00	1.00	Stepper motor opens target tray door of IBS #1 and stops.

MC applies current to IBS #1 muscle wire.	11:30	4.00	100.00	Muscle wire contracts, and projectile is released in IBS #1.
MC runs IBS #1 stepper motor.	13:14	20.00	5.00	Stepper motor closes target tray door in IBS #1 and stops.
MC turns off LEDs in IBS #1.	13:39	0.00	1.00	IBS #1 experiment complete.
MC signals camera 2 to stop recording.	13:40	1.00	5.00	Camera 2 stops recording.
MC turns off camera 2.	13:46	0.00	1.00	Camera 2 is off.
MC turns on camera 1.	13:47	0.00	5.00	Camera 1 is on in record mode.
MC signals camera 1 to record.	13:52	1.00	5.00	Camera 1 begins recording on videotape.
MC turns on LEDs in IBS #4.	13:58	0.00	5.00	IBS #4 has internal illumination.
MC runs IBS #4 stepper motor.	14:03	10.00	1.00	Stepper motor opens target tray door of IBS #4 and stops.
MC applies current to IBS #4 muscle wire.	14:14	4.00	100.00	Muscle wire contracts, and projectile is released in IBS #4.
MC runs IBS #4 stepper motor.	15:58	20.00	5.00	Stepper motor closes target tray door in IBS #4 and stops.
MC turns off LEDs in IBS #4.	16:23	0.00	1.00	IBS #4 experiment complete..
MC signals camera 1 to stop recording.	16:24	1.00	5.00	Camera 1 stops recording.
MC turns off camera 1.	16:30	0.00	5.00	Camera 1 is off.
MC turns on camera 2.	16:35	0.00	5.00	Camera 2 is on in record mode.
MC signals camera 2 to record.	16:40	1.00	5.00	Camera 2 begins recording on videotape.
MC turns on LEDs in IBS #2.	16:46	0.00	5.00	IBS #2 has internal illumination.
MC runs IBS #2 stepper motor.	16:51	10.00	1.00	Stepper motor opens target tray door of IBS #2 and stops.
MC applies current to IBS #2 muscle wire.	17:02	4.00	50.00	Muscle wire contracts, and projectile is released in IBS #2.
MC runs IBS #2 stepper motor.	17:56	20.00	5.00	Stepper motor closes target tray door in IBS #2 and stops.
MC turns off LEDs in IBS #2.	18:21	0.00	1.00	IBS #2 experiment complete.
MC signals camera 2 to stop recording.	18:22	1.00	5.00	Camera 2 stops recording.
MC turns off camera 2.	18:28	0.00	5.00	Camera 2 is off.
MC turns on camera 1.	18:33	0.00	5.00	Camera 1 is on in record mode.
MC signals camera 1 to record.	18:38	1.00	5.00	Camera 1 begins recording on videotape.
MC turns on LEDs in IBS #5.	18:44	0.00	5.00	IBS #5 has internal illumination.
MC runs IBS #5 stepper motor.	18:49	10.00	1.00	Stepper motor opens target tray door of IBS #5 and stops.
MC applies current to IBS #5 muscle wire.	19:00	4.00	180.00	Muscle wire contracts, and projectile is released in IBS #5.

MC runs IBS #5 stepper motor.	22:04	20.00	5.00	Stepper motor closes target tray door in IBS #5 and stops.
MC turns off LEDs in IBS #5.	22:29	0.00	1.00	IBS #5 experiment complete.
MC signals camera 1 to stop recording.	22:30	0.00	1.00	Camera 1 stops recording. Tape motion stops.
MC turns off camera 1.	22:31	0.00	0.00	Experiment complete.

2.0 Payload Description

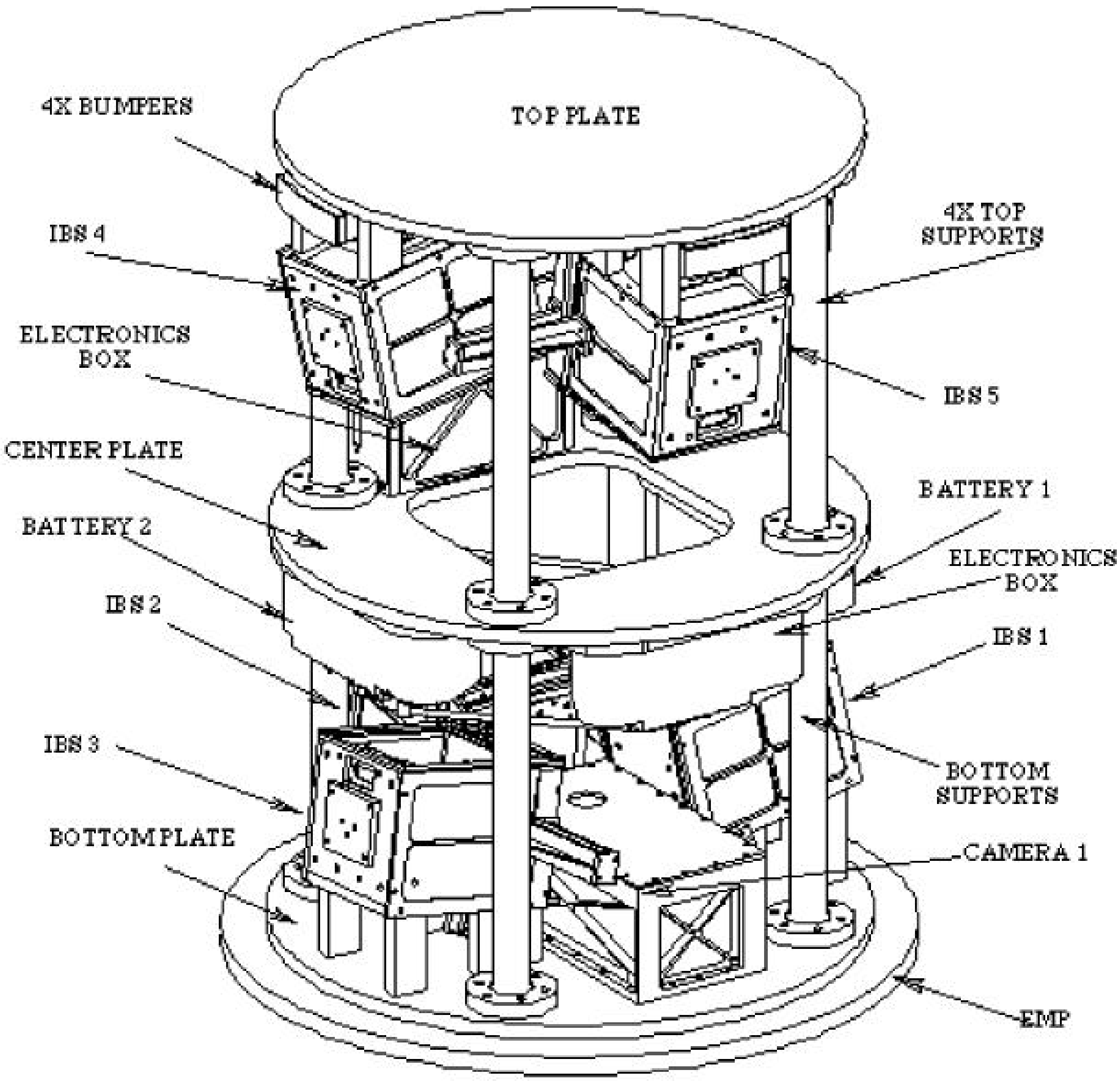
The COLLIDE main assembly is shown in figure 2.0-1. This includes the major components of the experiment: the six IBSs, two battery boxes, two camera containers, two electronics boxes, and support structure.

2.1 Support Structure

The COLLIDE primary structure will provide physical support to all experimental equipment during every phase of the mission. The entire support structure is comprised of 6061-T6 Aluminum due to its high strength-to-weight ratio, high corrosion resistance, and good machinability. The support structure is shown in figure 2.1-1. The structure consists of a top plate (0.450" thick and 19.25" diameter), a center plate (0.500" thick and 19.50" diameter), and a bottom plate (0.500" thick and 19.75" diameter), which are physically connected via eightsolid struts. These plates serve as the mounting surfaces for the COLLIDE experimental equipment, power system, and control system. The bottom plate (figure 2.1-2) attaches to the GASCAN EMP with twenty-two 10-32 A286 steel cap screws and holds a sealed camera container for camera 1 along with IBS's one,two, and three. The bottom plate has a 5" by 4" rectangular cutout to accomodate the GASCAN battery venting turret. The center plate serves as the mounting fixture for the two battery boxes and the two electronics boxes (figure 2.1-2). Each battery box is attached to the center plate with 24 #6-32 A286 steel cap screws into locking helicoils. One electronics box is attached to the center plate with 12 #6-32 A286 steel cap screws into locking helicoils. The other electronics box is attached to the center plate with 24 #6-32 A286 steel cap screws into locking helicoils. The center plate also has a rectangular hole 8.75" by 8.75" with 2.0" radius fillets machined from the center which acts as a view-port for the two JVC model GR-DV1 cameras. Attached to the top plate are one sealed camera container for camera 2, four viton lateral support bumpers, and IBSs four, five, and six. Each camera sealed container is attached to an end plate by 18 #8-32 A286 steel cap screws into locking helicoils. Each IBS is attached to an end plate with 8 #8-32 A286 steel cap screws into locking helicoils. The eight connecting COLLIDE struts are machined from solid 6061-T6 aluminum rod and are 1.2" in diameter and 13.375" long, with a 3" diameter flange of 0.500" thickness on each end. The top and bottom plates are connected to the struts with forty-eight 1/4"-20 heat-resisting steel cap screws (NAS1352N4-16). Locking helicoils of 0.375" length are inserted into the top and bottom plates to assure rigid connections. The center plate is secured with twenty-four 1/4"-20 heat-resisting cap screws of 1.75" length (NAS1352N4-28) which pass through the bottom flanges of the top four struts, through the center plate, and into 0.500" length locking helicoils inserted into the top flanges of the bottom four struts.

Analysis has verified that the first natural frequency of the payload is higher than 35 Hz.

Ultimate margins of safety were computed assuming a force application of 10g simultaneously in all three coordinate axes (figure 2.1-3). An ultimate factor of safety of 2.0 was used and the ultimate margins of safety for the G-772 support structure were computed and found to be positive.



G-772
COLLIDE MAIN ASSEMBLY VIEW
FIGURE 2.0-1

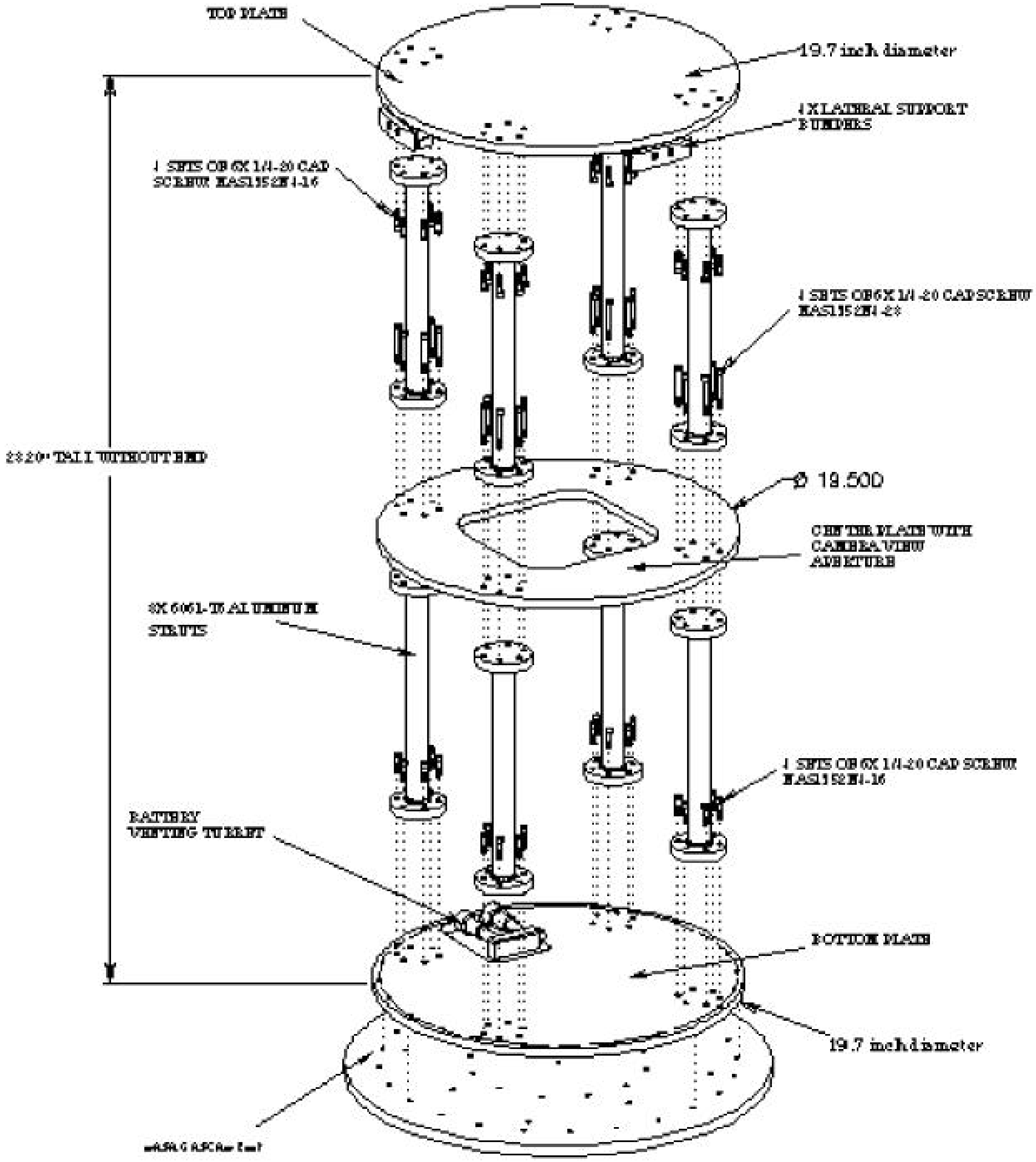
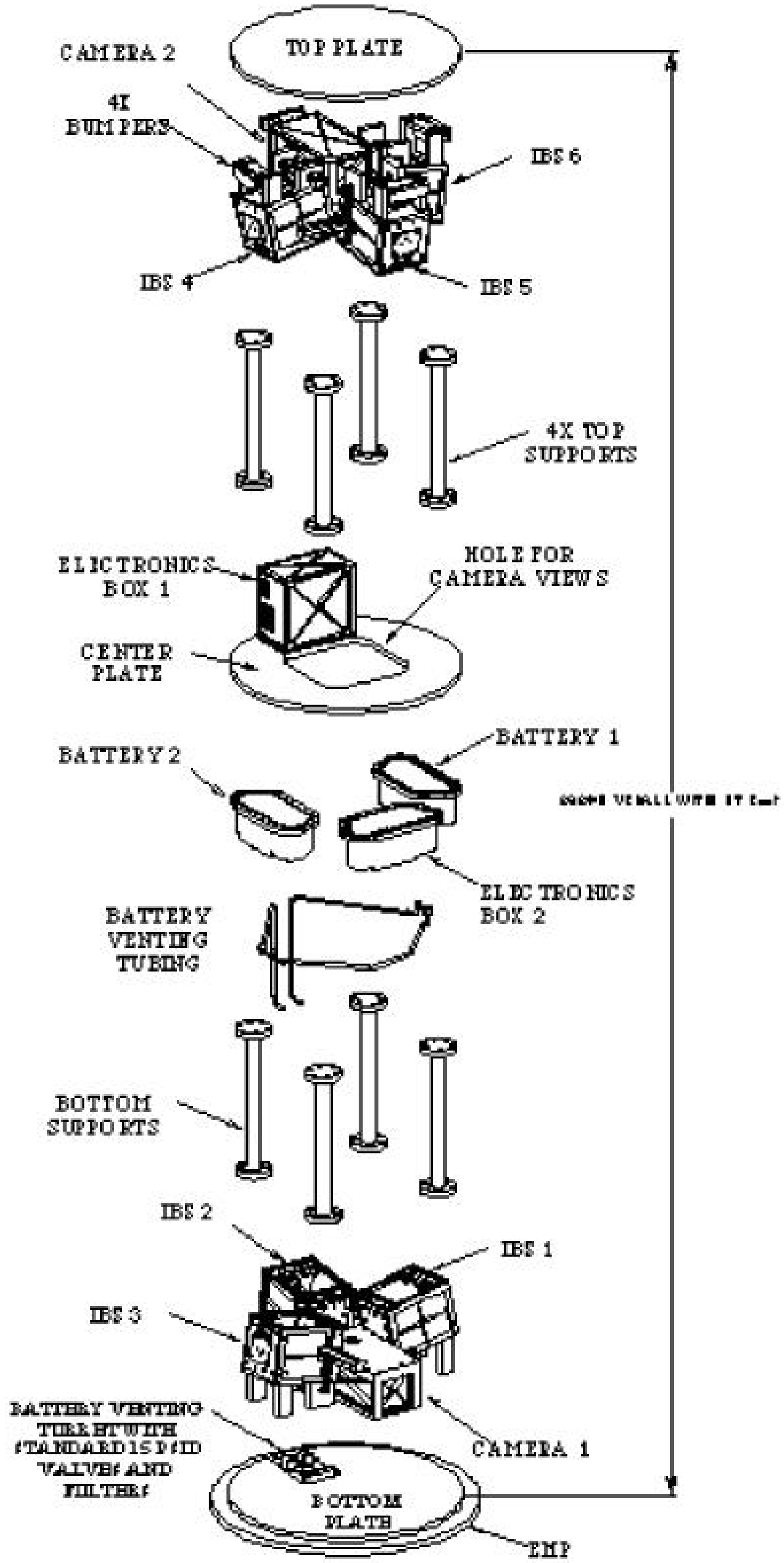


FIGURE 2.1-1
G-772 SUPPORT
STRUCTURE



G-772
EXPLODED VIEW
FIGURE 2.1-2

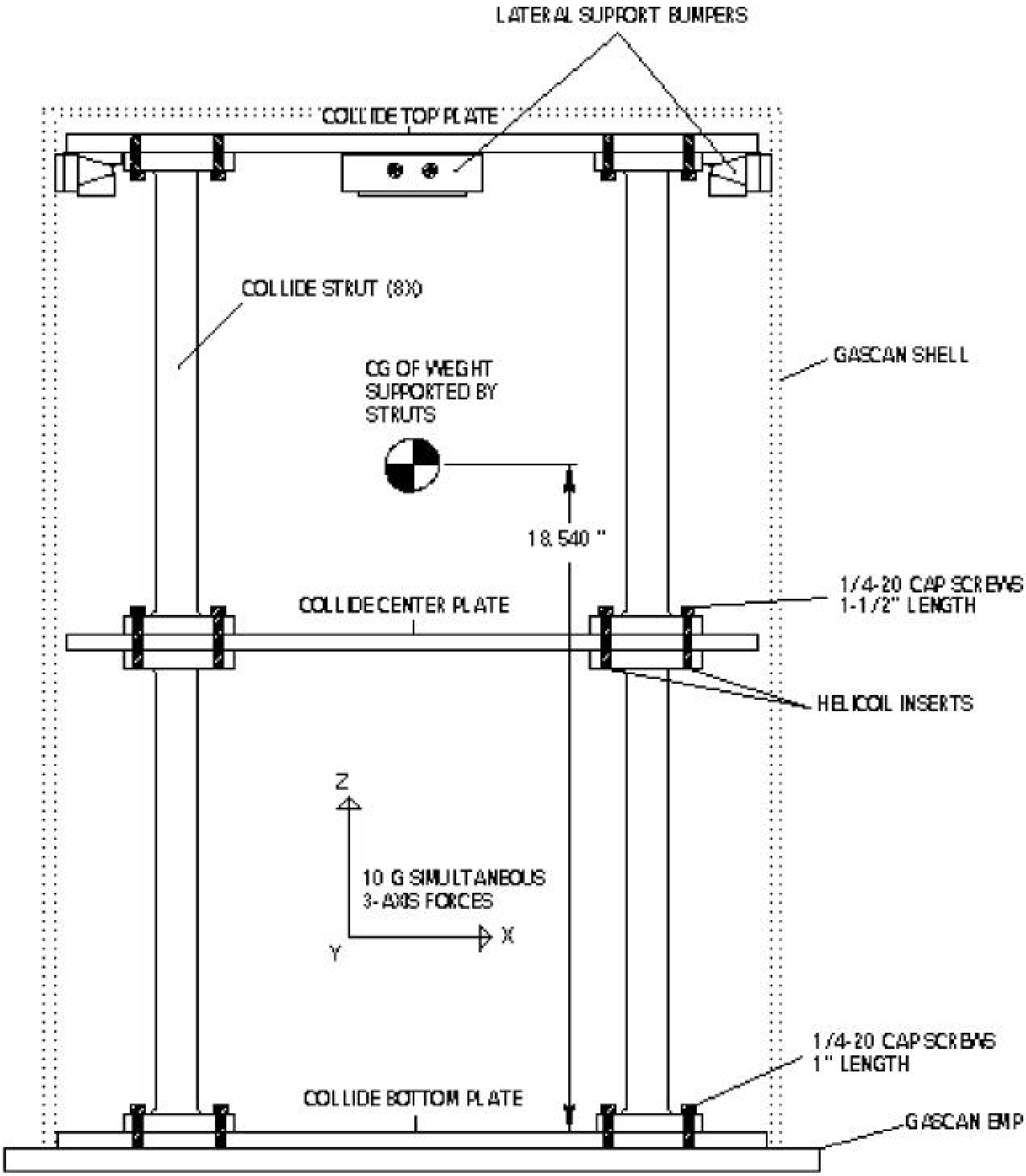
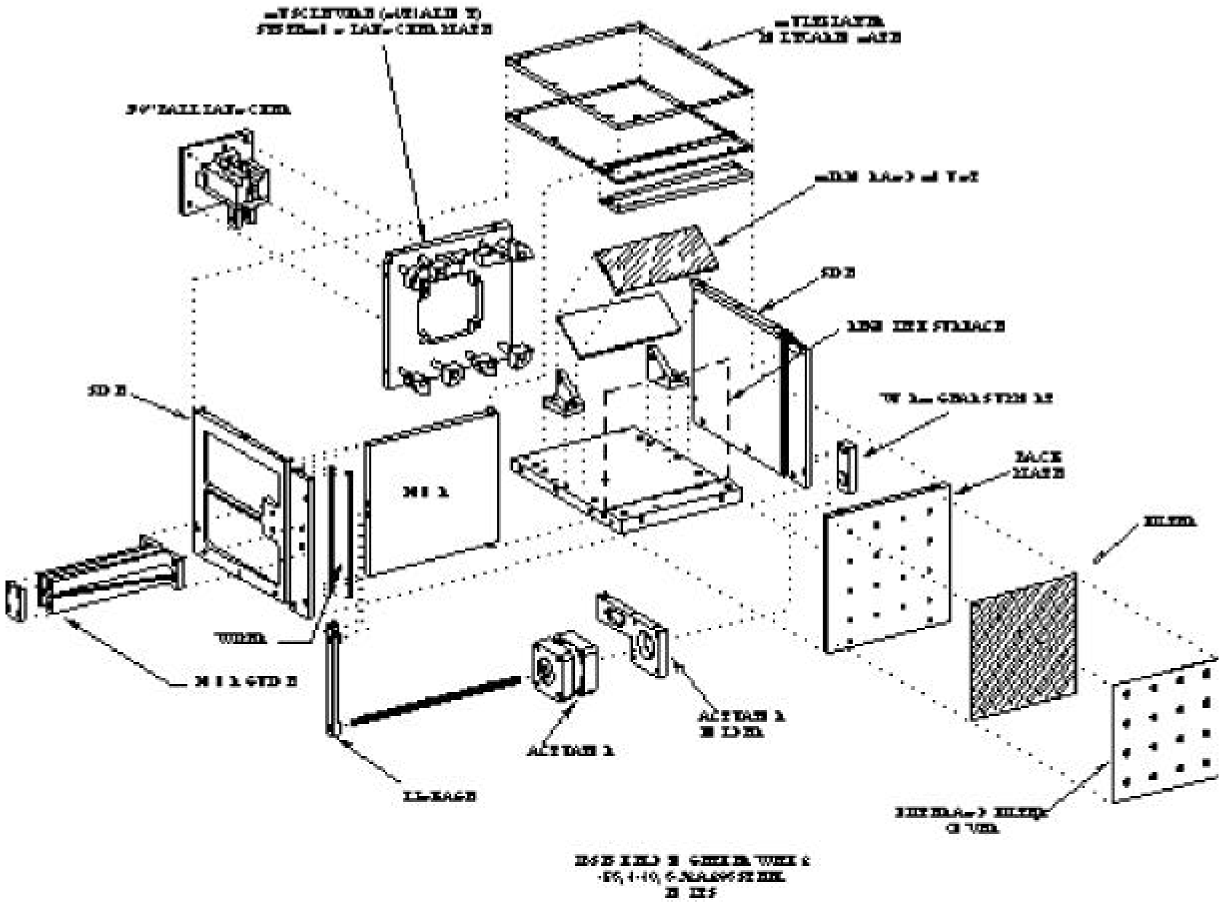


FIGURE 2.1-3
G-772 Primary Structure Configuration

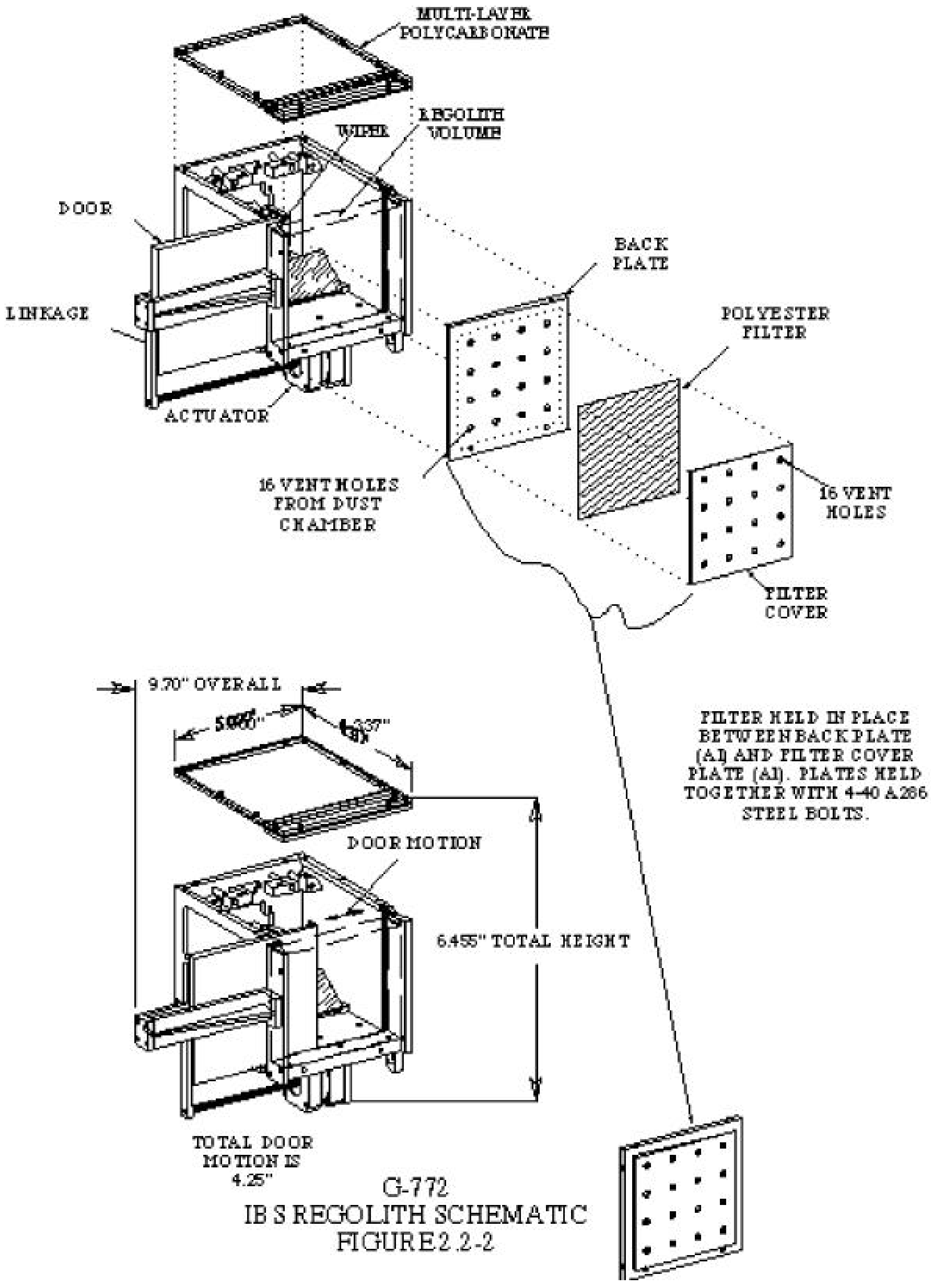
2.2 Impactor Box System

There are six Impactor Box Systems (IBS) in G-772. An exploded view is shown in figure 2.2-1, and schematic views showing the regolith placement and door operation are in figures 2.2-2 and 2.2-3. Each IBS performs a collision experiment into simulated lunar regolith with different collision parameters. The parameters that are varied between IBS's are (1) collision speed, (2) impactor size, and (3) regolith depth. The IBS is modular, and each is identical except for target tray depth, impactor size, mirror mount orientation, and the launcher springs which control the collision speed. Three IBS's are mounted on the bottom plate, and three IBS's are mounted on the top plate. The weight of each IBS (at 1 gravity) does not exceed five pounds. Each IBS has a transparent top made of two layers of polycarbonate to allow data recording by the video camcorder at the opposite end of the experiment. One end of each IBS has a tray approximately 3/4 inch deep containing JSC-1 ground basalt powder. At the opposite end of the IBS is the launcher subsystem, a mirror to provide a second view of the collision, and a lighting fixture. Lights will be high intensity LEDs. Fiduciary marks on the bottom of the IBS provide reference for later data analysis of ejecta trajectories.

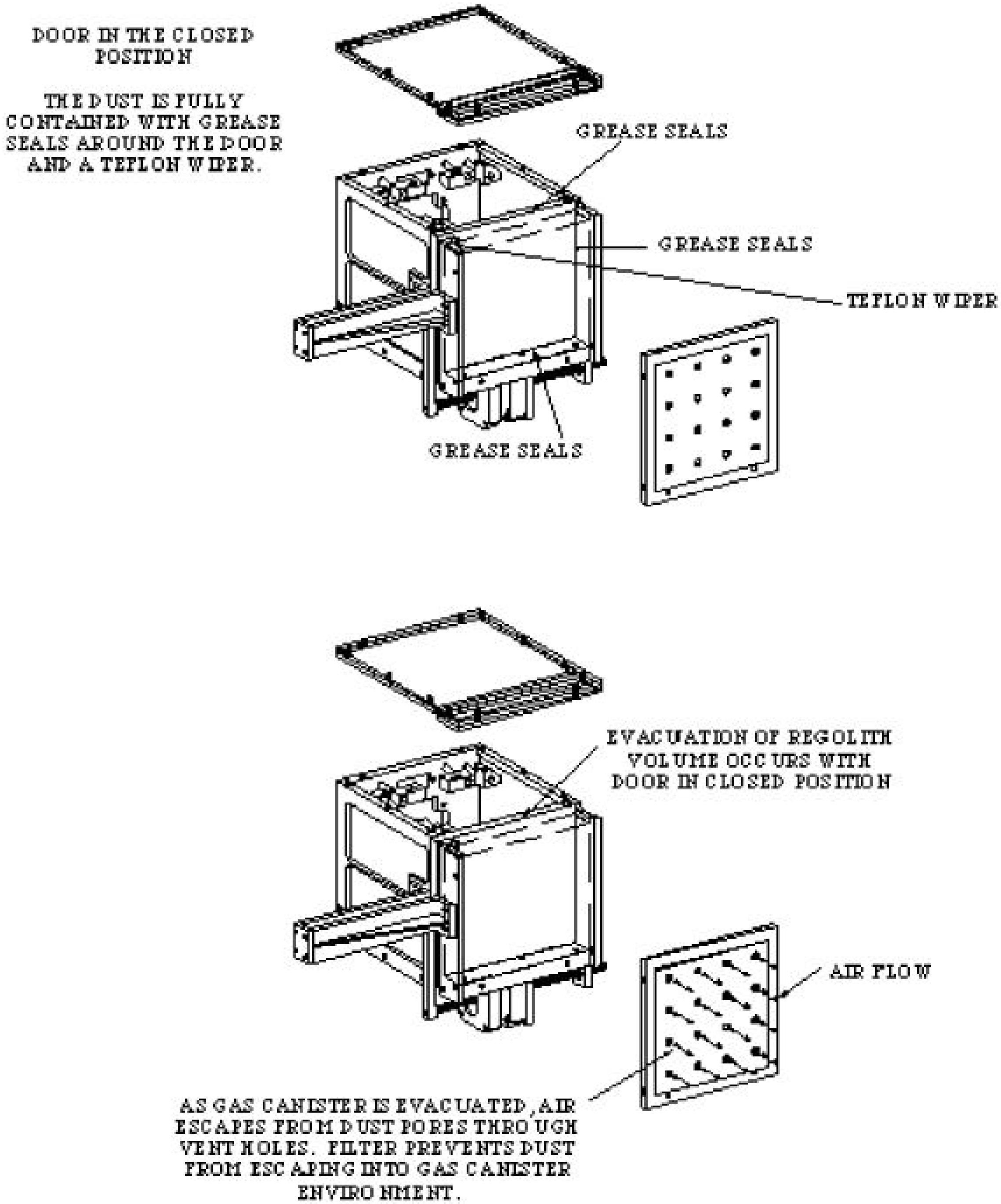
The IBS frames and doors are machined from 6061-T6 aluminum. In addition to the aluminum frame and polycarbonate top, each IBS includes a door with teflon pins which run through door guides, a digital linear actuator (stepper motor) from Eastern Air Devices (part number ZB17GBK P-11-6), and a fused electrical connector which supplies power to the launcher subsystem, stepper motor, and lighting subsystem. The IBS's are not sealed containers. The IBS's are assembled with A286 steel bolts into locking helicoils. Each IBS is attached to an end plate with four 6061-T6 aluminum stands. The IBS is attached to the stands with two #8 A286 steel bolts and locking helicoils for each stand, and each stand is attached to the end plate with two #8 A286 steel bolts and locking helicoils.



G-772
EXPLODED IBS VIEW
FIGURE 2.2-1



G-772
IBS REGOLITH SCHEMATIC
FIGURE 2.2-2



G-772
IBS DOOR SCHEMATIC
FIGURE 2.2-3

2.2.1 Launcher Subsystem

The launcher subsystem is mounted at the opposite end of the IBS (figure 2.2-4). The projectile is a teflon sphere, either 3/8 inch or 3/4 inch in diameter, depending on the particular IBS. The projectile is launched by the launcher spring. Prior to the experiment, the projectile is held in place by a spring-loaded release lever, or launcher door. This door is released when a spring-loaded plunger is pulled by a shape memory alloy (Muscle Wire) circuit (figure 2.2-5). A circuit of 8 inches of Muscle Wire will be heated by passage of 0.75 Amps of current through the circuit, causing the wire to contract and pull the plunger. The pins supporting the Muscle Wire are 416 steel press fit into the launcher mounting plate of the IBS. The Muscle Wire is a Nickel-Titanium alloy with a diameter of 250 micrometers. If the Muscle Wire circuit "fails on" then it will remain in its contracted state without damage and without damaging any of the associated components of the IBS until the circuit is broken or the battery voltage is exhausted. The launcher subsystem for each IBS is fused for mission success.

The launcher subsystem includes three springs: the plunger spring, the door spring, and the launcher spring. The plunger spring in each IBS is identical. The door spring in each IBS is identical. The launcher springs differ in each IBS. Table 2.2-1 gives constants and displacements for each spring in each IBS. The total amount of energy that could possibly be stored in all 18 springs in G-772 is 1.84×10^{10} ergs which is insufficient to breach an IBS. The actual stored spring energy wil be much less because we will not compress the springs by their full length.

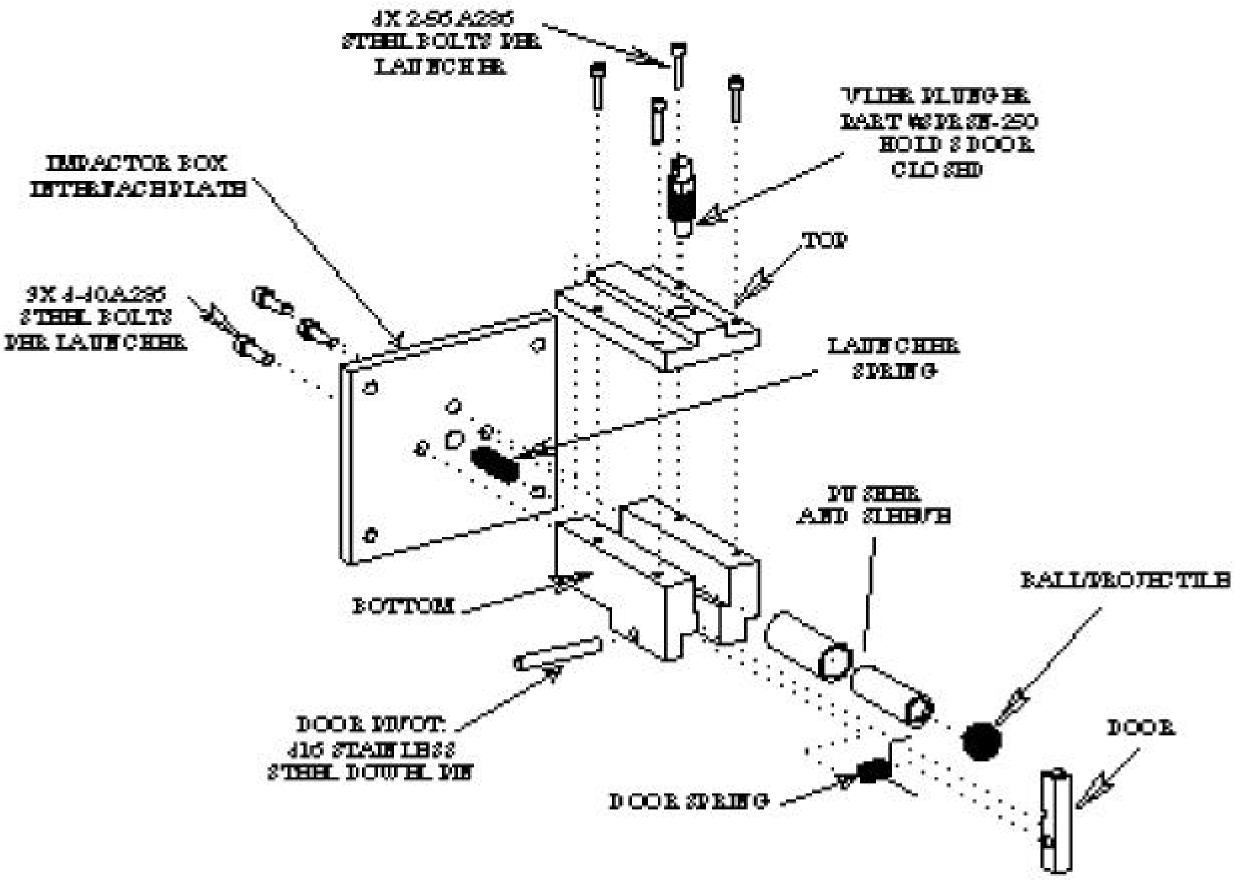
Table 2.2-1 Spring Data

IBS	Launcher Spring Constant (lbs./in.)	Launcher Spring Length /Displacement (in.)	Door Spring Constant(lbs/in.)	Maximum Door Spring Displacement (in.)	Plunger Constant (lbs./in.)	Plunger Displacement (in.)
1	0.1301	0.63 / 0.1	1	1.8	10	0.25
2	2.803	0.63 / 0.1	1	1.8	10	0.25
3	74.784	0.63 / 0.1	1	1.8	10	0.25
4	2.803	0.63 / 0.1	1	1.8	10	0.25
5	0.007125	0.63 / 0.1	1	1.8	10	0.25
6	22.572	0.63 / 0.1	1	1.8	10	0.25
Total possible spring energy (ergs):			1.84×10^{10}			

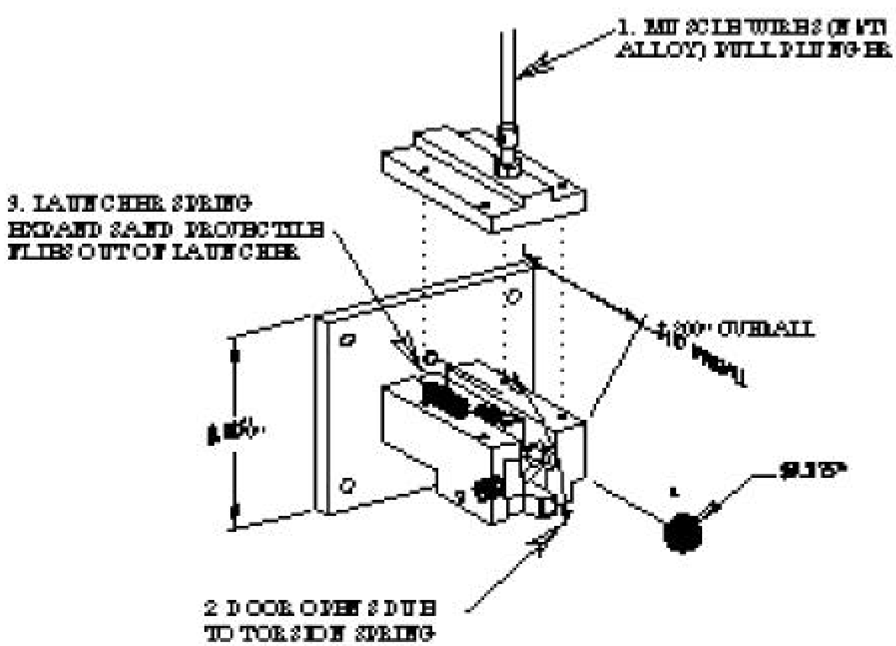
Table 2.2-2 Projectile Data

IBS	Projectile Mass (grams)	Projectile Velocity (cm/sec)	Projectile Energy (ergs)
1	0.98	4.64	10.6
2	0.98	21.5	2.27×10^2
3	7.8	100.0	3.9×10^4
4	0.98	21.5	2.27×10^2
5	0.98	1.00	0.49
6	0.98	100.0	4.9×10^3
Total Projectile Kinetic Energy (ergs):		4.44×10^4	

EXPLODED VIEW

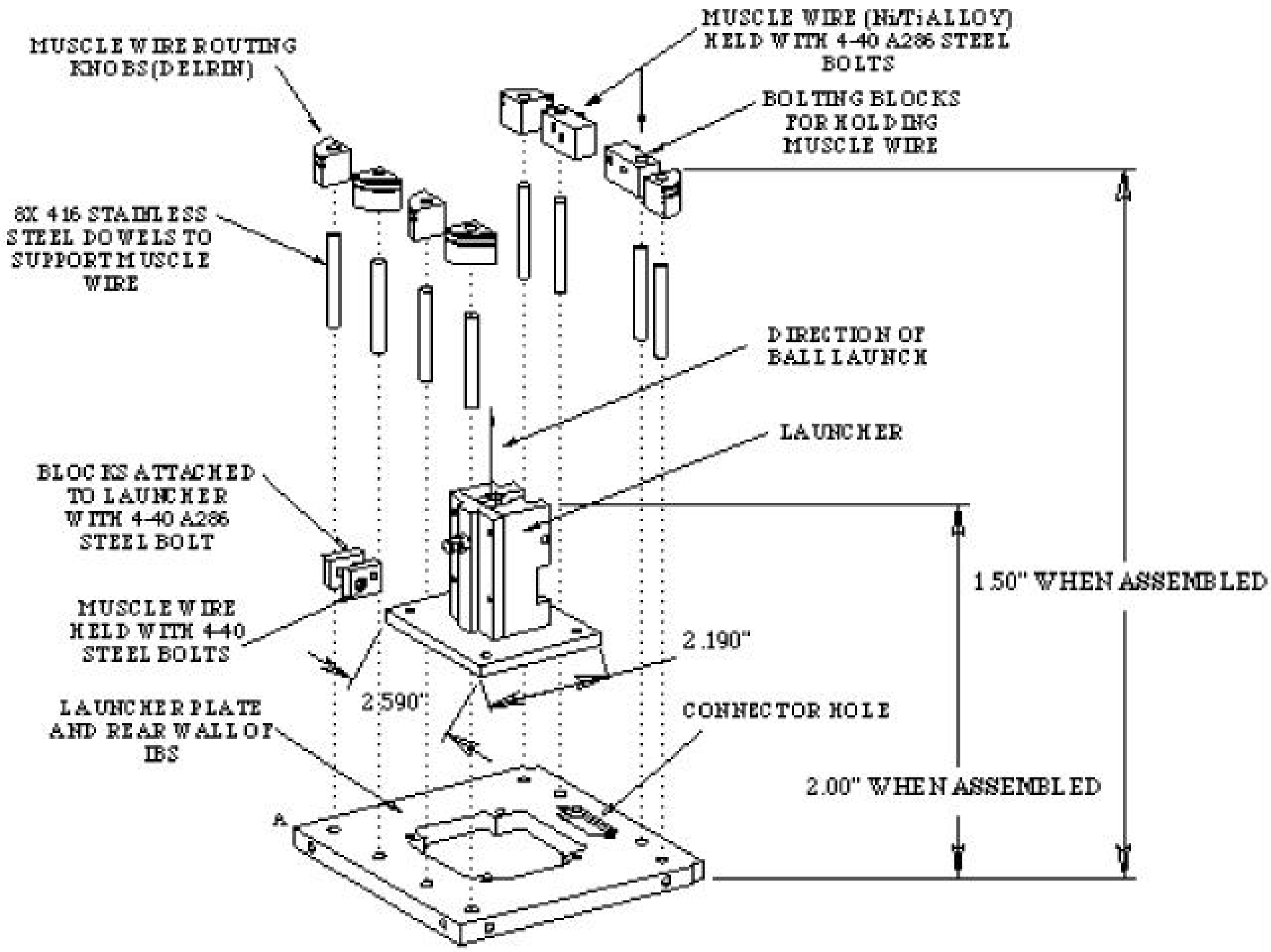


FUNCTION VIEW

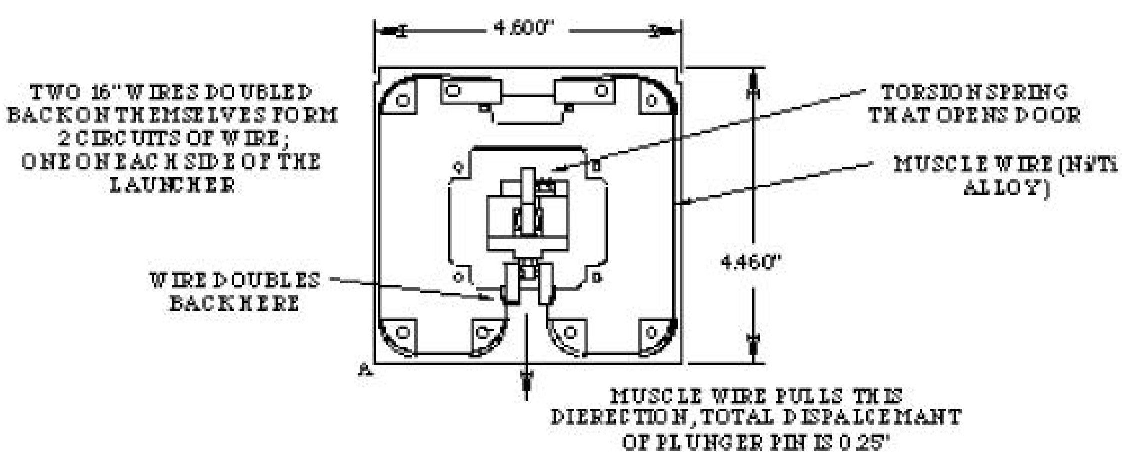


G-772
LAUNCHER
FIGURE 2.2-4

MUSCLE WIRES SYSTEM EXPLODED VIEW



MUSCLE WIRE FACE VIEW



G-772
MUSCLE WIRE SYSTEM
FIGURE 2.2-5

2.2.2 Target Tray Subsystem

The target tray at one end of each IBS is filled with JSC-1, a fine volcanic powder. The mean and median particle sizes are near 100 microns. The specific gravity of the powder is 2.9 gm/cm^3. The depth of the trays ranges from 3/8 to 3/4 inches. Before the experiment is initiated, the powder is held in place by a door. When the cannister is evacuated prior to launch, pore spaces in the powder will evacuate through a polyester filter (Filtra/Spec, Inc. Style #12-4-1013 rated to 10 microns) mounted over 16 pressure relief holes at the bottom of the target tray. Five IBS's will contain 0.85 pounds (388 grams) of JSC-1, and the sixth IBS will contain 0.43 pounds (197 grams). The total amount of JSC-1 is 4.7 pounds (2.137 kilograms).

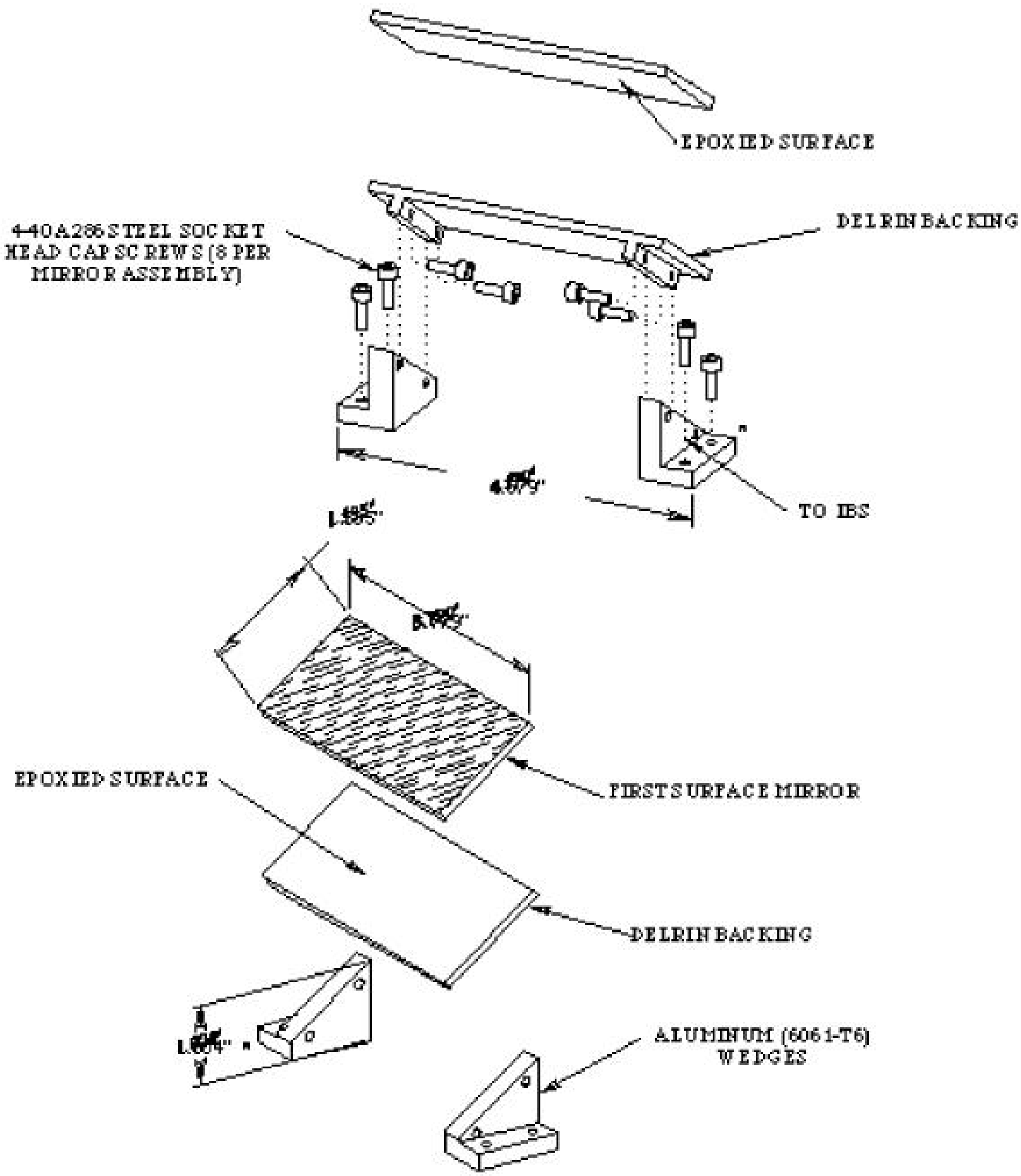
The door is opened by a stepper motor mounted to the exterior of the IBS. A door restraint brace prevents the door from becoming detached from the IBS in the event of a door-motor linkage failure. Each door stepper motor will be fused for mission success. The stepper motor for each IBS is from Eastern Air Devices, Inc. model number ZB17GBKP-11-6. The motor is a bi-directional device and is totally enclosed with permanently lubricated ball bearings. The internal rotating nut is made of SAE 660 bearing bronze and the actuating shaft is made of cold rolled steel. The motors run on 6 VDC and exert a maximum linear force of 16 pounds, and have a weight of 7 ounces. The force exerted decreases with increasing speed of rotation. At the rate of opening of the target tray doors in the experiment (0.5 inches per second), the linear force exerted is 7 pounds. In order to overcome possible sticking at the start of door motion, the motor will be operated at a speed of 0.1 inches per second for one second providing a maximum inital linear force when opening and closing the door of 15 pounds. The current drawn by the motor is 0.63 Amps/phase, and the linear travel is 0.625 thousandths of an inch per 1.8 degree step of the internal rotating nut.

2.2.3 Lighting and Optics Subsystem

Illumination of each IBS will come from high-intensity light emitting diodes (LEDs) mounted on a circuit board at the launcher end of the IBS. Each board will contain 20 LEDs. The LED boards for each IBS are fused for mission success. The LEDs are Hewlett Packard LEDs (serial number HLMP8103). Their peak forward current is 300 milliAmps with an average forward current of 30 mA. Power dissipation through each LED in G-772 will be approximately 66 mW, for a total power dissipation, with associated resistors, of 2.0 W for each IBS lighting board. The luminous intensity of the LEDs at 20 mA is 4.5 candelas, and the typical radiant intensity is 35.3 mW per steradian.

Each IBS includes a mirror mounted to provide the camera on the opposite end plate a view of the impact on the surface of the JSC-1 (figure 2.2-6). The mirror in each IBS is a first surface mirror. The mirror backing is polycarbonate, 1.535 inches by 3.779 inches by 0.1 inches with a mass of 11.8 grams (0.026 pounds). On the first surface is a thin layer of Aluminum. The polycarbonate has been tested against breakage with projectiles with 100 times more energy than the total projectile kinetic energy in COLLIDE without damage. The delrin backing with the mirror affixed to it will be bolted with four #4-40 A286 steel socket head cap screws to two Aluminum (6061-T6) wedges which, will in-turn be bolted to the IBS base plate with four #4-40 A286 steel socket head cap screws. Each IBS will have one mirror with mountings for a payload total of 6 mirrors, six delrin backings, 12 wedges and 48 #4-40 socket-head cap screws.

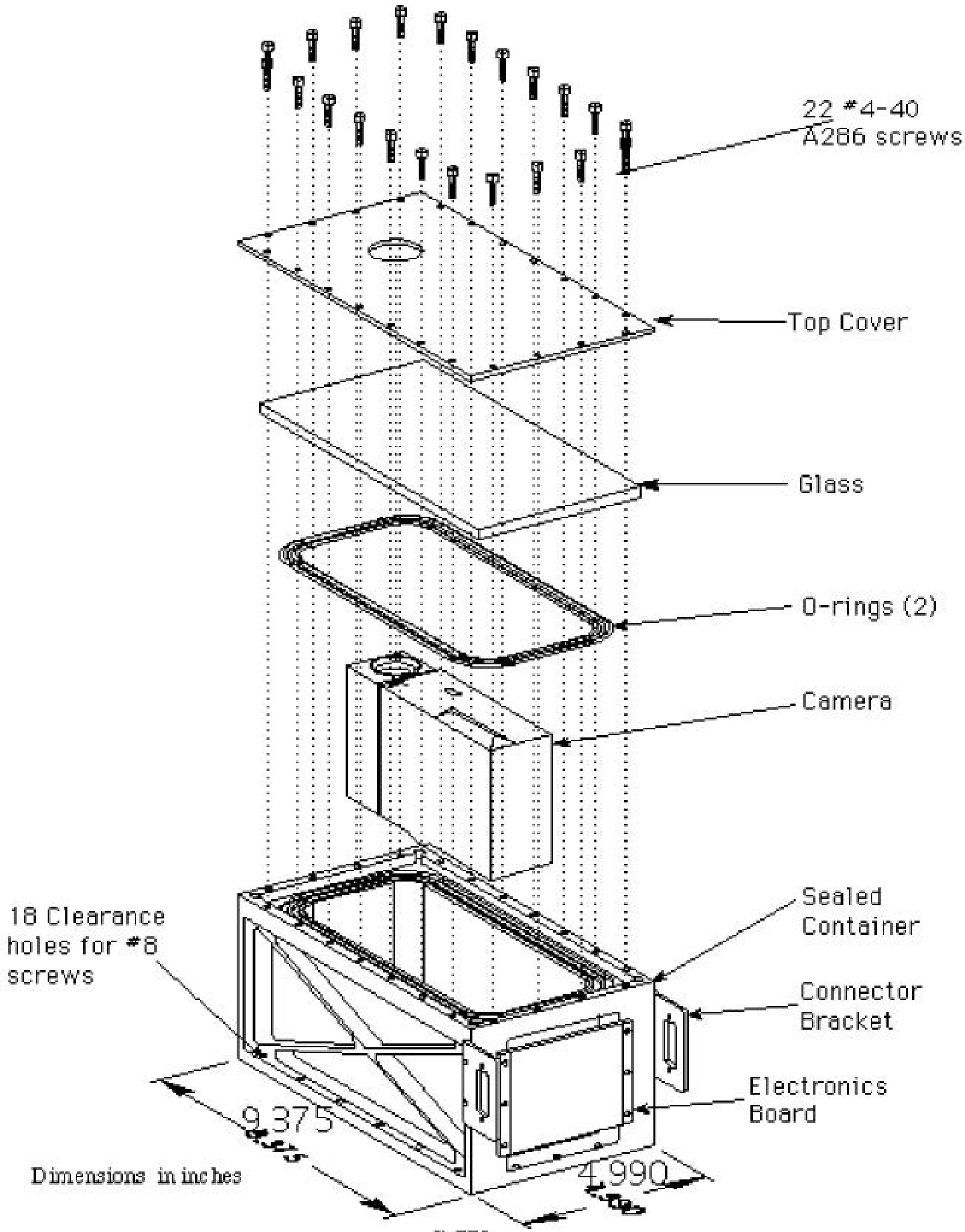
MIRROR ASSEMBLY



G-772
MIRROR ASSEMBLY
FIGURE 2.2-6

2.3 Camera System

On the bottom plate, in between the three IBS's, a video camcorder ("camera") is mounted with a view of the IBS's on the top plate through the hole in the central plate. A second camera is mounted on the top plate with a view of the IBS's on the bottom plate. For mission success, the cameras are in sealed containers (figure 2.3-1). The IBS's are oriented so that the camera has an edge-on view of the target powder surface and a view of the mirror within the IBS providing a head-on view of the impact location on the powder surface. A hole in the central plate allows the camera field of view to reach the end of the Launcher Subsystem within each IBS. Each camera is a JVC GR-DV1 digital video camcorder. Two packets of silica gel dessicant are in each camera sealed container. The cameras are held in place in the containers by rubber foam pieces and teflon tape. The cameras will draw power from the main experiment battery pack. Each camera is fused for mission success. No other batteries are used for the cameras. Internal lithium ion batteries have been removed from the cameras. For mission success the cameras will be heated by turning them on to keep the tape within the 0 to 40 degree Centigrade operating range during the experiment. The cameras' own internal heat dissipation is used; no external heaters are used. The sealed containers are made of 6061 T-6 aluminum with glass viewing ports. The camera sealed containers are 9.375 inches long by 4.99 inches wide by 4.155 inches high. The quartz glass for the viewing port is contained inside the sealed container and is 8.865 inches long by 4.42 inches wide by 0.25 inches thick. The mass of each piece of glass is 351 grams (0.772 pounds). The viewing port is circular and has a diameter of 1.182 inches. The sealed container is assembled with 22 heat treated stainless steel A286 #4-40 bolts to hold the top plate on over the glass. The container is mounted to the end plate with 18 stainless steel A286 #8-32 cap screws into locking helicoils. Two viton o-rings will be used for each sealed container between the container and the container top. The o-rings are static axial seals from Apple Rubber Products. They are circular with outside diameters of 6.621 inches and 7.163 inches respectively and will be fit into grooves between the sealed container and glass plates. A control circuit board is mounted on the end of each camera sealed container by 4 #4 A286 heat treated corrosion-resistant screws (figure 2.3-1).



G-772
CAMERA SEALED
CONTAINER
FIGURE 2.3-1

2.4 Batteries

The power system consists of 2 stacks of 9 Duracell alkaline (Zn/MnO_2) D cells, for a total of 18 D cells, in 2 sealed containers connected by stainless steel tubing to form one battery box volume. No additional cells are used and no lithium cells are present in the payload. The battery box is vented through the battery turret to the cargo bay, using the NASA supplied 15 psid pressure relief valves. Battery specifications are in table 2.4-1 and the battery system configuration is summarized in table 2.4-2. A schematic of the power system is in figure 2.4-1. The battery box mechanical design is in figure 2.4-2. Each battery container is 9.71 inches by 4.728 inches by 3.446 inches high. Each is held in place by 24 6-32 A286 stainless steel bolts. Each battery container has 2 venting ports with steel fixtures leading to stainless steel tubing, and the battery box is vented overboard through two sets of stainless steel tubing via the NASA supplied 15 psid pressure relief valves. The battery box has been proof pressure tested to 22.5 psid. Free volume has been minimized and has been filled with cotton as an absorbant material. The interior of the battery box is coated with G11 fiberglass, an electrolyte resistant non-conductive material. The terminals are coated with Kapton tape to prevent shorting between cells. The batteries are encased in Teflon, an electrolyte resistant non-conductive material. The Teflon encasing secures the individual battery cells. The cell arrangement is shown in figure 2.4-2

Table 2.4-1 Battery Specifications

Manufacturer	Duracell
Manufacturer's Part Number	MN1300
Type of Battery	Alkaline-Manganese Dioxide (Zn/MnO_2)
Size	D
Nominal Voltage	1.5V
Rated Capacity	15,000mAh at 10 Ω to 0.8V at 21°C
Average Mass	138 g
Average Volume	56.4 cm^3
Terminals	Flat
Operating Temp. Range	-20°C to 54°C

Table 2.4-2 System Battery Configuration

Number of Batteries per Stack	9
Number of Stacks	2
Total Number of Batteries	18
Nominal Voltage per Stack	13.5V

2.5 Electrical

The two parallel strings of 9 D cells are diode isolated with International Rectifier 12FR10 diodes. The batteries will be fused on the ground leg by a 7 Amp slow-blow fuse inside the box as close to the negative terminal of the battery as possible (figure 2.4-2). Wires are 18 AWG with a 200 degree C temperature rating. The power circuit runs through the PPC and is open until the barometric switch latches Relay A HOT on ascent and closes the power circuit. A schematic of the electronics is shown in figure 2.5-1. Table 2.5-1 lists the amount of current in each of the major lines in the payload, and table 2.5-2 lists all payload components and their power dissipation. The total Watt-hours of the battery is 406 Watt-hours at 25 degrees C. There are no other batteries in G-772.

2.6 Command and Data Handling

The command and data handling subsystem operates the various components of the payload in the correct sequence. A timer circuit and self-diagnostic circuit will initiate the experiment if the battery voltage approaches levels that may jeopardize the successful operation of the experiment or more than 24 hours has elapsed since the baroswitch latched Relay A to HOT. It consists of an Intel 80C51GB microcontroller with associated support circuitry. Flight engineering data and pressure, accelerometry, and temperature data are recorded on EEPROM chips using power from the G-772 battery pack. Science data are recorded by the camcorder videotapes.

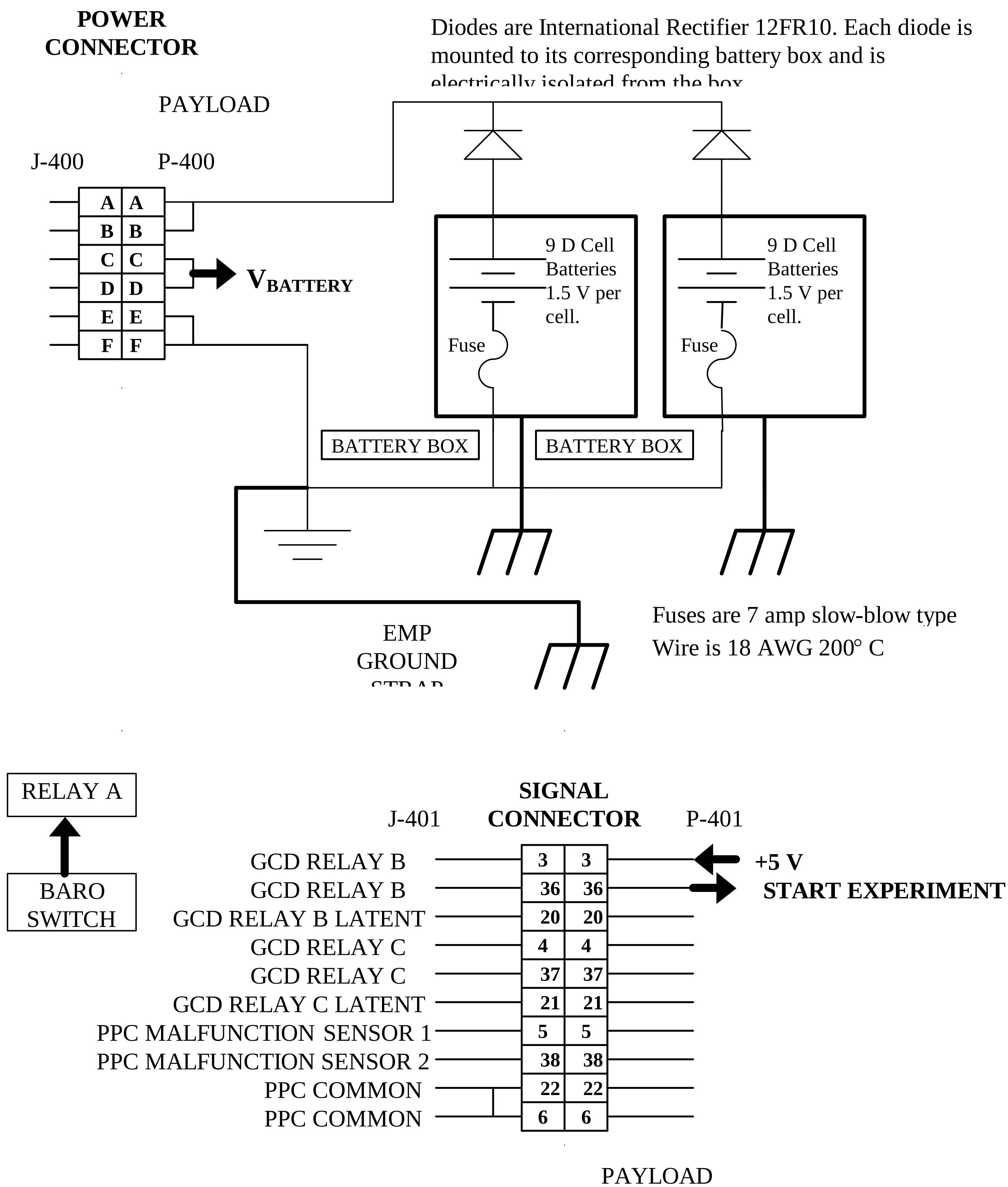
2.7 Materials

The G-772 materials have been selected in accordance with JSC 09604. Structural materials have been selected in accordance with MSFC-SPEC-522 to comply with Stress Corrosion Cracking (SCC) requirements. The materials used in G-772 have been assessed by the NASA GSFC Materials Branch/Code 313 for compatibility with the standard sealed GAS carrier system materials (seals, valves, electronics, and structures). The materials have also been assessed for compatibility within and among experiment subsystems. All materials have been reviewed and approved for flight by the GSFC Materials Branch/Code 313.

2.8 Thermal

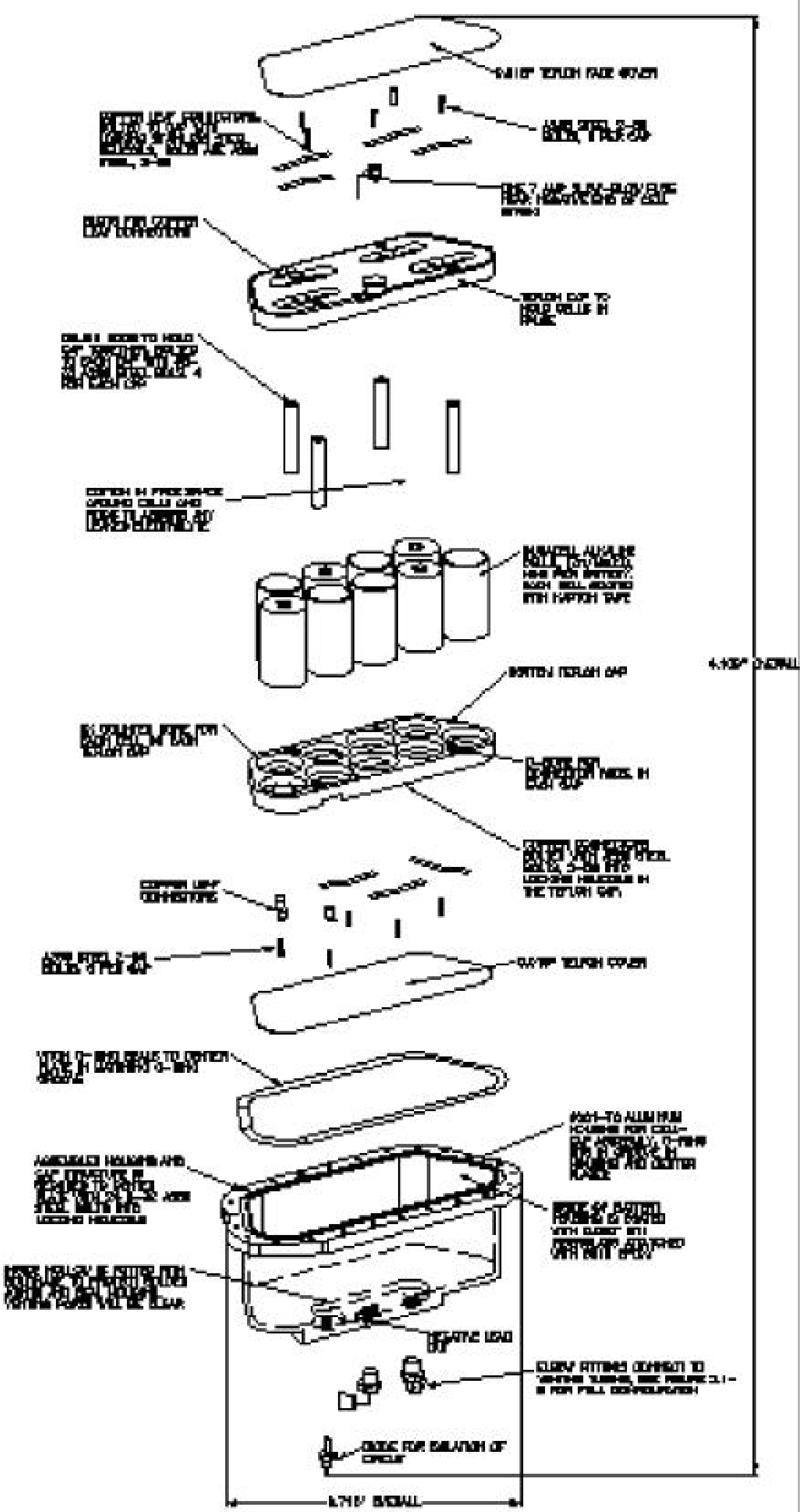
For mission success the thermal subsystem of G-772 consists of a temperature sensor and insulation within each camera sealed container for each video camcorder.

COLLIDE Power System



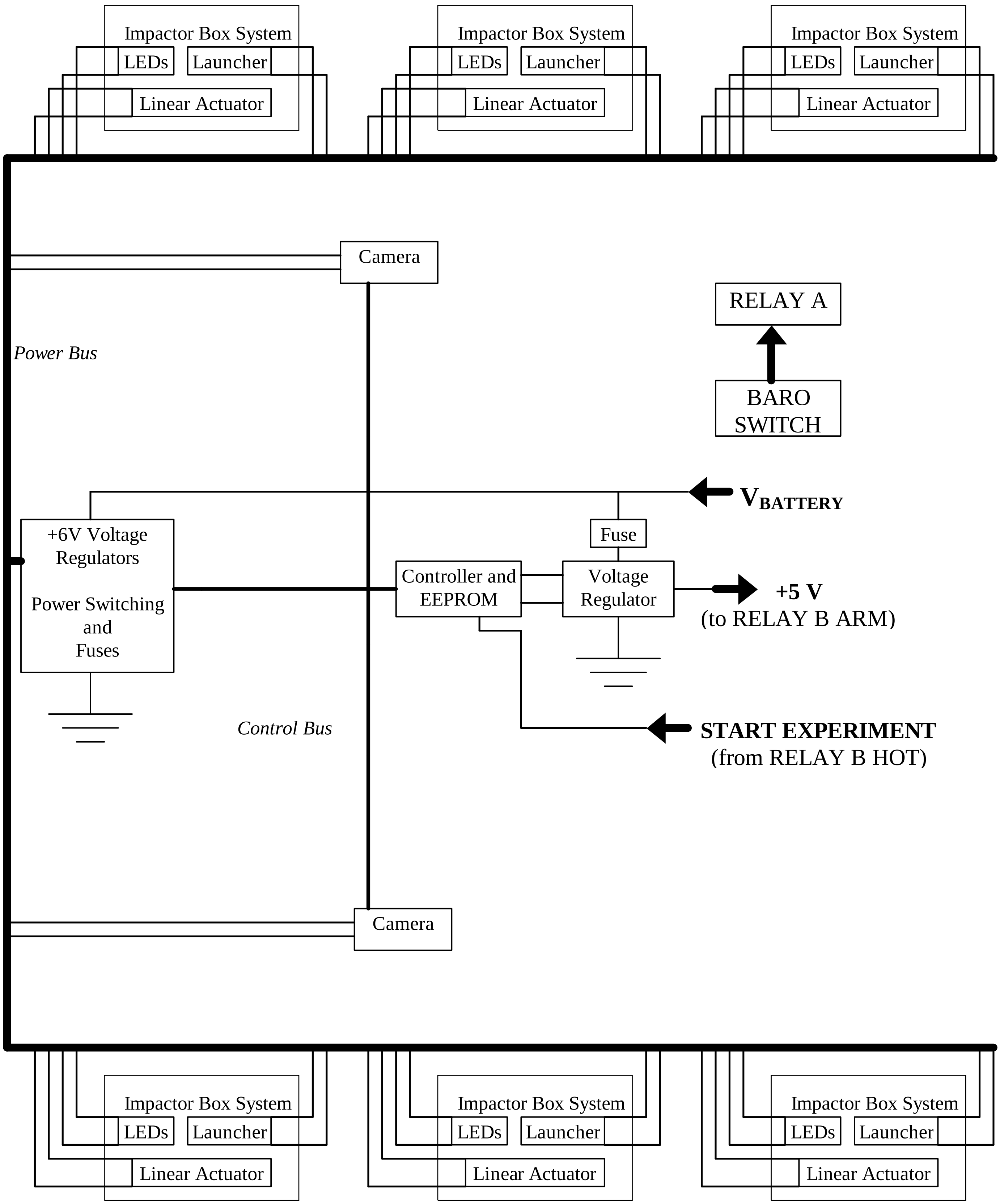
G-772
POWER SCHEMATIC
FIGURE 2.4-1

BATTERY ASSEMBLY



G-772
BATTERY BOX
FIGURE 2.4-2

COLLIDE Electronics System



G-772
FIGURE 2.5-1

Table 2.5-1 Currents in Major Payload Lines

Line	Current (A)
+5V Voltage Regulator	≤ 0.3
+6V Voltage Regulator (for each camera, 2 total)	1.215
+6V Voltage Regulator for LEDs, Muscle Wire, Stepper Motors (each, 2 total)	1.815
Relay B Arm	≤ 0.005
Camera	1.2
LEDs / Impactor Box	0.3
Launcher / Impactor Box	1.5
Linear Actuator / Phase (4 phases/ Impactor Box)	0.63
Battery (total for all battery stacks)	≤ 3.34
Total if everything fails on	≤28.68

Note: Currents in some lines are given as upper limits because some devices may not be on at all times.

Table 2.5-2 Power Dissipation

Component	Power Dissipation (W)
Battery Diode / Battery Box	≤ 1.67
+5V Voltage Regulator	≤ 2.25
+6V Voltage Regulator (for each camera, 2 total)	7.9
+6V Voltage Regulator for LEDs, Muscle Wire, Stepper Motors (each, 2 total)	≤ 11.8
Controller, EEPROM, Sensors, Clock	≤ 1.5
Camera	7.2
LEDs / Impactor Box	1.8
Launcher / Impactor Box	9.0
Linear Actuator, 2 phases on per Impactor Box	7.56
Maximum under normal operation	**45**
Total if everything fails on	**387**

Note: Battery voltage of 13.5V is assumed for power calculations.
Note: Power for some components is given as an upper limit because some devices may not be on at all times.

3.0 Flight Safety

3.1. Hazard Assessment

A safety analysis has been performed for this payload in compliance with NSTS 1700.7B. The results are contained in the attached Safety Matrix, Hazard Descriptions, and Hazard Reports. Credible hazards have been identified and described in detail. Hazards were eliminated from the payload whenever possible, and the remaining hazards have been studied and associated hazard reports have been generated.

Three areas of concern with regard to flight have been identified for this payload. They are associated with: structural failure, battery corrosion or explosion, and mechanical collision hazards. This payload is classified as Class B in accordance with the policy set forth in JSC Letter TA-91-029.

The concerns associated with the electrical system are short circuit, reverse current, over discharge, battery box overpressure, release of battery gasses accompanied by an ignition source, and leakage of battery electrolyte. The precautions taken are as follows: the battery boxes are sealed and vented through two redundantly vented NASA standard 15 psid PRVs; the battery box is lined with a non-reactive, non-conductive material (G11 fiberglass, cotton, and delrin); battery strings are fused on the negative leg inside the battery box with 7-Amp slow-blow fuses as close to the batteries as possible. The batteries are diode isolated with International Rectifier 12FR10 diodes. The free volume within the battery boxes has been minimized and is filled with cotton as an absorbing material. Wires are 18 AWG wires with a temperature rating of 200 degrees C.

The structural and mechanical hazards have been minimized by design. To ensure structural stability, the structure has been designed and built to withstand the appropriate limit loads with an ultimate factor of safety of 2.0. The fundamental frequency of the experiment support structure is greater than 35 Hz about any axis. In the event of an experiment support structure failure, the experiment will be contained within the standard, sealed, 5.0 cubic foot GAS canister.

3.1.1 Energy Containment Analysis Summary

This experiment includes stored energy in the batteries that is dissipated through electrical devices. The hazards associated with batteries are assessed in Hazard Report G-772-F-02.

The G-772 experiment is contained within a sealed and evacuated GAS canister providing a non-flammable environment within the GAS canister. The worst case for the G-772 experiment would be for all electrical components to fail on while in a HOT Space Shuttle attitude. In total, this represents 387 Watts of power dissipation on a continual basis until battery depletion (1.05 hours). Thermal analysis shows that the final GAS canister temperature under these worst case conditions with a starting temperature of 40 degrees C would be 64 degrees C and the associated GAS canister pressure would increase from its pressure at launch by less than 18 per cent. Since the GAS canister will be evacuated prior to launch to a pressure of 0.0001 atmospheres, the worst case GAS canister pressure would be less than 0.0002 atmospheres. This means the GAS canister would remain sealed because the canister is relieved by 2 and 3 atmosphere pressure relief valves. The canister has been proof qualified to over 7 atmospheres. Therefore the experiment is safe by design and no manifestation of any experiment control failure presents a safety threat to the Space Shuttle or crew.

3.1.2 Structural Containment Analysis Summary

Hazard Report G-772-F-01 documents GAS canister containment of the failed experiment structure.

The structural members of the payload have been verified for flight worthiness as documented in the Structural Analysis. Fracture control practices are compliant to GSFC 731-0005-83B. Analysis has verified that the first natural frequency of the payload is higher than 35 Hz. Appropriate limit loads incorporating an ultimate factor of safety of 2.0 were used for the design of G-772 hardware, and show positive margins. The materials used were suitable for the applications, and conform to MSFC-SPEC-522B (Table I) and MSFC-HDBK-527. The documentation associated with structures (analyses, testing and materials) has been submitted, reviewed, and approved by GSFC.

3.1.3 Mechanical Summary

This experiment includes stored mechanical energy in 18 springs. The launcher springs have spring constants of less than 75 lbs/in, with displacements of 0.1 inch. The door plungers have spring constants less than 10 lbs/in with displacements of 0.25 in. and the door springs have spring constants less than 1 lbs/in with displacements of 0.5 in. The total energy that could possibly be stored in the 18 springs is less than 1.84*10^10 ergs using the full length of the launcher springs. Using the actual displacement of the launcher springs gives a stored spring energy of 7*10^9 ergs. The total kinetic energy of the 6 projectiles is 4.44x10^4 ergs. Test launches of steel projectiles with a kinetic energy more than 100 times the total experiment projectile kinetic energy did not damage the IBS. The projectiles will be contained by the IBS's. The stored spring energy in G-772 is insufficient to damage the GAS canister.

3.2 Hazard Control Verification

The hazard solutions for credible hazards detailed in Section 3.1 have been verified in the following manner.

3.2.1 Electrical

Battery safety controls such as cell configuration/security, fusing as appropriate to wire size, battery box coating, proof pressure testing, use of NASA PRVs, and diode isolation have been verified by design review at NASA GSFC. Implementation of the design will be confirmed by inspection during integration at KSC and will be tracked on the VTL. The purging of the battery boxes and evacuation of the GAS canister will be performed at the integration site by NASA GSFC personnel and will be tracked on the Verification Tracking Log.

3.2.2 Structural

Structural analysis indicating appropriate limit loads with an ultimate factor of safety over 2.0 and a fundamental frequency about any axis greater than 35 Hz has been performed. The analysis has been reviewed and approved by NASA GSFC. NASA GSFC has performed an analysis to show containment of experiments up to 200 pounds (GAS-CAN01-014, Perforation Analysis, April 26, 1990).

3.2.3 Mechanical

An analysis of the total stored spring energy and total projectile kinetic energy has shown that the energy is insufficient to damage the IBS or the GAS canister. Drop tests of teflon and steel projectiles with energies up to 100 times the total projectile kinetic energy in G-772 have been performed and did not damage IBS components. The analysis has been reviewed and approved by NASA GSFC.

3.3 Hazard Forms

Safety Data Matrix
Hazard Descriptions
Hazard Reports

GAS PAYLOAD SAFETY MATRIX - FLIGHT OPERATIONS

PAYLOAD	PAYLOAD ORGANIZATION	DATE	PAGE
G-772	LASP - UNIVERSITY OF COLORADO	Sep. 22,‘97	1

HAZARD GROUP / SUBSYSTEM	COLLISION	CONTAMINATION	CORROSION	ELECTRICAL SHOCK	EXPLOSION	FIRE	TEMPERATURE EXTREMES	RADIATION		
BIOMEDICAL										
RADIATION										
STRUCTURES	X									
ELECTRICAL			X		X					
ENVIRONMENTAL CONTROL										
HUMAN FACTORS										
HYDRAULICS										
MATERIALS										
MECHANICAL										
OPTICAL										
PRESSURE SYSTEMS										
PYROTECHNICS										

FIGURE 3.3-1

GAS HAZARD DESCRIPTION - FLIGHT OPERATIONS		
PAYLOAD NUMBER & ORGANIZATION G-772 COLLIDE LASP, UNIVERSITY OF COLORADO	SUBSYSTEM PAYLOAD	DATE Sep. 22 1997

HAZARD GROUP	BRIEF DESCRIPTION OF HAZARD	APPLICABLE SAFETY REQUIREMENTS
Structures/Collision	- Failure of payload primary structure - Impactor Box System breaks off primary structure	206 Failure Propagation 208.1 Structural Design 208.2 Emergency Landing Loads 208.3 Stress Corrosion
Electrical/Corrosion	- Leakage of battery electrolye	206 Failure Propagation 208.5 Sealed Compartments 209 Materials 213.2 Batteries 219 Flammable Atmospheres
Electrical/Explosion	- Rupture of battery cells	206 Failure Propagation 208.5 Sealed Compartments 213.2 Batteries

FIGURE 3.3-2

<table>
<tr><td colspan="2">PAYLOAD HAZARD REPORT</td><td colspan="2">No. G-772-F-01</td></tr>
<tr><td colspan="2">PAYLOAD G-772</td><td colspan="2">PHASE III</td></tr>
<tr><td>SUBSYSTEM Structures</td><td>HAZARD GROUP Collision</td><td colspan="2">DATE July 16, 1997</td></tr>
<tr><td colspan="4">HAZARD TITLE Failure of Experiment Support Structure</td></tr>
<tr><td colspan="2" rowspan="3">APPLICABLE SAFETY REQUIREMENTS

NSTS 1700.7B: 206 Failure Propagation,
208.1 Structural Design,
208.2 Emergency Landing Loads
208.3 Stress Corrosion</td><td colspan="2">HAZARD CATEGORY</td></tr>
<tr><td></td><td>Catastrophic</td></tr>
<tr><td>X</td><td>Critical</td></tr>
<tr><td colspan="4">DESCRIPTION OF HAZARD
During launch/landing operations, the experiment support structure fails resulting in release of the experiment inside the GAS canister.</td></tr>
<tr><td colspan="4">HAZARD CAUSES
1. Inadequate structural design for launch and landing environment.
2. Improper materials selection.</td></tr>
<tr><td colspan="4">HAZARD CONTROLS
1. (a) Fundamental frequency of experiment about any axis exceeds 35 Hz.
(b) Support structure designed to an ultimate Factor of Safety of 2.0 over appropriate limit loads with positive margins of safety.
2. Materials selected in accordance with stress corrosion requirements of MSFC-SPEC-522B, Table I.</td></tr>
<tr><td colspan="4">SAFETY VERIFICATION METHODS
1.
(a) Vibration analysis.
(b) Structural analysis.
(c) GAS Canister Containment Analysis. Standard Sealed GAS Canister Assembly/Integration Procedure.
2. GSFC Materials Branch (Code 313) to review.</td></tr>
<tr><td colspan="4">STATUS OF VERIFICATION
1.
(a) Open.
(b) Open.
(c) Open.
2. Open.</td></tr>
<tr><td rowspan="4">PHASE III APPROVALS</td><td>GAS P/L Manager</td><td colspan="2">GAS Safety Officer</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>GAS Project Manager</td><td colspan="2">STS</td></tr>
<tr><td></td><td colspan="2"></td></tr>
</table>

Figure 3.3-3

<table>
<tr><td colspan="2">PAYLOAD HAZARD REPORT</td><td colspan="2">No. G-772-F-02</td></tr>
<tr><td colspan="2">PAYLOAD G-772</td><td colspan="2">PHASE III</td></tr>
<tr><td>SUBSYSTEM Electrical</td><td>HAZARD GROUP Explosion/Corrosion</td><td colspan="2">DATE July 16, 1997</td></tr>
<tr><td colspan="4">HAZARD TITLE Rupture of Duracell Alkaline "D"-size battery cells</td></tr>
<tr><td colspan="2" rowspan="3">APPLICABLE SAFETY REQUIREMENTS
NSTS 1700.7B: 206 Failure Propagation
208.5 Sealed Compartments
213 Electrical Systems; 209 Materials
219 Flammable Atmospheres</td><td colspan="2">HAZARD CATEGORY</td></tr>
<tr><td></td><td>Catastrophic</td></tr>
<tr><td>X</td><td>Critical</td></tr>
<tr><td colspan="4">DESCRIPTION OF HAZARD Rupture of Alkaline battery cells and the release of battery electrolyte.</td></tr>
<tr><td colspan="4">HAZARD CAUSES
1. Battery overcurrent/short circuit.
2. Evolution of hydrogen and oxygen in the presence of an ignition source.
3. Electrolyte leakage.
4. Cell reversal.</td></tr>
<tr><td colspan="4">HAZARD CONTROLS
1. (a) In accordance with JSC 20793, the negative ground leg of each string is fused within the battery boxes to protect the battery from an overcurrent condition. The fusing meets the wire/fuse criteria of JSC letter TA-92-038.
(b) Battery boxes internal coating is non-conductive.
2. (a) Batteries are contained in sealed battery boxes (proof pressure tested to 22.5 psi).
(b) Battery boxes are redundantly vented overboard using 15.0 psid valves.
(c) Battery boxes purged with nitrogen.
(d) Contained in a sealed GAS canister that is evacuated.
3. (a) Battery boxes internal coating are inert to electrolyte.
(b) Use of absorbent material in battery boxes.
4. Parallel cell strings are diode isolated.</td></tr>
<tr><td colspan="4">SAFETY VERIFICATION METHODS
1. (a) Design review (see attached electrical schematic Figure H/R#G-772-2-1).
(b) Design review; Materials review.
2. (a) Proof pressure test of battery boxes.
(b) Standard PRV refurbishment checkout.
(c) Battery boxes purged with nitrogen by GAS Field Operations personnel.
(d) GAS can evacuated by GAS Field Operations personnel. Standard Sealed GAS Canister Assembly/Integration Procedure.
3. (a) Design review.
(b) Design review.
4. Design review (see attached electrical schematic Figure H/R#G-772-2-1).</td></tr>
<tr><td colspan="4">STATUS OF VERIFICATION
1. (a) Open. (b) Open.
2. (a) Open.
(b) CLOSED TO THE VTL. To be performed at KSC (Procedure number GAS37 -300-11).
(c) CLOSED TO THE VTL. To be performed at KSC (Procedure number GAS CA N-08-011).
(d) CLOSED TO THE VTL. To be performed at KSC (Procedure number GAS CAN -08-011).
3. (a) Open. (b) Open.
4. Open.</td></tr>
<tr><td rowspan="4">PHASE III APPROVALS</td><td>GAS P/L Manager</td><td colspan="2">GAS Safety Officer</td></tr>
<tr><td></td><td colspan="2"></td></tr>
<tr><td>GAS Project Manager</td><td colspan="2">STS</td></tr>
<tr><td></td><td colspan="2"></td></tr>
</table>

Figure 3.3-4

4.0 Ground Safety

This section describes the ground safety aspects of G-772 Ground Support Equipment (GSE) and operations.

4.1 Ground Support Equipment

Ground support equipment for G-772 consists of miscellaneous tools for final assembly of components, such as pliers, wrenchs, and screwdrivers for final assembly of the experiment. Also included are the following items:

JVC AC Adaptor Charger AA-V70U. UL 4C43

Fluke 70 Series II Multimeter UL#950Z

The electrical power required for all payload GSE can be satisfied by standard 15 amp, 110 VAC outlets and by payload batteries.

4.2 List of Operations

All ground support operations will take place in the GAS preparation area.

The payload will be delivered to KSC partially assembled. The JSC-1 target powder will not be in the IBS's when the payload is delivered, and the flight battery packs will not be in the battery boxes when delivered. These items will be installed during ground operations. There will be no functional testing of G-772 hardware at KSC. The impact chambers of the IBS's will not be opened. The sequence of activities includes the following steps:

1. Remove payload from shipping container.
2. Disassemble support structure.
3. Remove battery boxes from central plate.
4. Remove (6) IBS's from support structure.
5. Remove (2) camera sealed containers from support structure.
6. Remove control board from logic box.
6. NASA GSFC personnel inspect payload.
7. Test (2) flight battery strings' voltage levels with multimeter.
8. Install flight battery strings into battery boxes.
9. Fill (6) IBS target trays
   (a) Remove target tray back plate and filter.
   (b) Fill target trays with JSC-1 pre-sifted and pre-weighed powder.
   (c) Reattach target tray back plate and filter.
10. Operate (2) cameras with AC adaptor to exercise tape
    (a) Fast-forward tape to end of tape.
    (b) Rewind tape to beginning of tape.
    (c) Set camera to record mode.
    (d) Record on tape for 10 minutes.
11. Install (2) cameras, temperature sensors, and insulation in sealed containers on end plates.
12. Attach (6) IBS's to end plates.
13. Reattach battery boxes to central plate.
14. Replace control board in logic box.
15. Attach logic box to central plate.
16. Attach top and bottom plates to central plates with struts.

17. Connect control and power connectors from logic box to each IBS and sealed containers.
18. NASA personnel perform nitrogen purge of battery boxes.
19. Integration of experiment into flight container.
20. NASA personnel evacuate GAS canister.

4.3 Hazard Assessment

A safety assessment for ground hazards has been completed and two hazards have been identified. There is the risk of electrical shock when installing the battery packs or due to improper installation of the batteries. The hazard will be minimized by design of checklist and tested sequence of operations on the ground, and by rehearsals prior to arrival at KSC. A hazard report has been generated for this hazard.

4.4 Hazard Control Verification

Hazard control verification for ground activities associated with G-772 will be achieved by design review.

4.5 Hazard Forms

Safety Data Matrix
Hazard Descriptions
Hazard Reports

GAS PAYLOAD SAFETY MATRIX - GROUND OPERATIONS

PAYLOAD	PAYLOAD ORGANIZATION	DATE	PAGE
G-772	LASP - UNIVERSITY OF COLORADO	JUL 16 '97	2

HAZARD GROUP / SUBSYSTEM	COLLISION	CONTAMINATION	CORROSION	ELECTRICAL SHOCK	EXPLOSION	FIRE	TEMPERATURE EXTREMES	RADIATION		
BIOMEDICAL										
RADIATION										
STRUCTURES										
ELECTRICAL				X						
ENVIRONMENTAL CONTROL										
HUMAN FACTORS										
HYDRAULICS										
MATERIALS										
MECHANICAL										
OPTICAL										
PRESSURE SYSTEMS										
PYROTECHNICS										

FIGURE 4.5-1

GAS HAZARD DESCRIPTION - GROUND OPERATIONS		
PAYLOAD NUMBER & ORGANIZATION G-772 COLLIDE LASP, UNIVERSITY OF COLORADO	SUBSYSTEM ELECTRICAL	DATE Apr. 25 1997

HAZARD GROUP	BRIEF DESCRIPTION OF HAZARD	APPLICABLE SAFETY REQUIREMENTS
Electrical Shock	- Battery pack connected to experiment or GSE hardware	4.2.1.1 Human Error 4.3.2 Electrical

FIGURE 4.5-2

<table>
<tr><td colspan="2">PAYLOAD HAZARD REPORT</td><td>No. G-772-G-01</td></tr>
<tr><td colspan="2">PAYLOAD G-772 - COLLIDE</td><td>PHASE III</td></tr>
<tr><td>SUBSYSTEM Electrical</td><td>HAZARD GROUP Electrical Shock</td><td>DATE July 16, 1997</td></tr>
<tr><td colspan="3">HAZARD TITLE Battery pack installation error.</td></tr>
<tr><td colspan="2" rowspan="3">APPLICABLE SAFETY REQUIREMENTS

KHB 1700.7B 4.2.1.1 Human Error
4.3.2.1 Electrical Requirements
4.3.2.2 Grounding, Bonding, and Shielding</td><td>HAZARD CATEGORY</td></tr>
<tr><td>☐ Catastrophic</td></tr>
<tr><td>X Critical</td></tr>
<tr><td colspan="3">DESCRIPTION OF HAZARD During normal ground operations, a ground crew member receives an electrical shock.</td></tr>
<tr><td colspan="3">HAZARD CAUSES
1. Human error when operating electrical devices.
2. Ground support equipment not properly grounded.
3. Exposed electrical contacts, conductors, or connectors.</td></tr>
<tr><td colspan="3">HAZARD CONTROLS
1. (a) Insulating gloves to be used when installing batteries.
(b) Checklist for experiment checkout to be used.
2. (a) GSE is UL listed
(b) Non-UL listed GSE is design-reviewed.
3. (a) There are no payload voltages over 13.5 VDC.
(b) All electrical connections are labeled to prevent mismating.
(c) All external parts and surfaces of the payload and GSE are at ground potential at all times.</td></tr>
<tr><td colspan="3">SAFETY VERIFICATION METHODS
1. (a)-(b) Design review.
2. (a)-(b) Design review.
3. (a)-(c) Design review.</td></tr>
<tr><td colspan="3">STATUS OF VERIFICATION
1. (a)-(b) Open.
2. (a)-(b) Open.
3. (a)-(c) Open.</td></tr>
<tr><td rowspan="4">PHASE III APPROVALS</td><td>GAS P/L Manager</td><td>GAS Safety Officer</td></tr>
<tr><td></td><td></td></tr>
<tr><td>GAS Project Manager</td><td>STS</td></tr>
<tr><td></td><td></td></tr>
</table>

Figure 4.5-3